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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS, ABSTRACTS OF PAPERS, AND

REPORTS OF THE PROCEEDINGS

OF THE SOCIETY

FROM NOVEMBER 1892 *TO NOVEMBER* 1893.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. NOVEMBER 11, 1892. No. 1

E. B. KNOBEL, President, in the Chair.

The Rev. James Barnes Brearley, M.A., F.R.G.S., St. James's Church, Oldham, Lancashire;
Herbert Hancock, M.A., F.R. Met. Soc., Bancroft's School, Woodford, Essex;
Thomas Torrens Knowles, M A., Royal Grammar School, Lancaster;
Alfred Thomas Odell-Sorrell, St. Mary's Grove, Chiswick, W.;
Edward Stroud, Prisca Coborn Foundation School, Tredegar Square, E.;
John Tatlock, jun., M.A., New York, U.S.A.,

were balloted for and duly elected Fellows of the Society.

Professor W. L. Elkin, Yale College, New Haven, Conn., U.S.A.;
Professor J. C. Kapteyn, Observatory, Groningen, Holland;
Professor Hugo Seeliger, Observatory, Munich, Bavaria;
Dr. Hermann Struve, Observatory, Pulkowa, Russia,

were balloted for and duly elected Associates of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Joseph Ibbitson Berry, 20, Alwyne Road, Canonbury, N. (proposed by W. S. B. Woolhouse);
Martin Brendel, Ph.D, Privat-docent of the University, Greifswald, Germany (proposed by H. H. Turner);
Ernest Gould Dixon, Teacher and Graduate of the College of Preceptors, 78, Alderney Street, S.W. (proposed by John Newton);
Harold Dennis Taylor, Optical Manager to Messrs. T. Cooke and Sons, 20, Bootham Terrace, York (proposed by Albert Taylor).

Two hundred and ten presents were announced as having been received since the last meeting, including, amongst others,

part of a series of photographic portraits of the Presidents of the Society, made and presented by Mr. W. Schooling; C. Flammarion, La planète Mars, presented by the author; Barlow and Bryan, Elementary Mathematical Astronomy, presented by Mr. W. T. Lynn; A. Guillemin, Autres Mondes, presented by the author; Catalogue of Proper-motion Stars, by J. G. Porter, presented by the Cincinnati Observatory; Oxford University Observatory, Researches in Stellar Parallax by the aid of Photography, Part 2, presented by the Observatory; H. Gyldén, Nouvelles recherches sur les séries employées dans les théories des Planètes, presented by the author; E. L. Trouvelot, Drawing of a portion of the Milky Way, presented by M. Trouvelot (per Mr. A. Marth); Lick Observatory, Photographs of the Moon and *Jupiter* (enlarged positives on glass), presented by the Observatory; Sydney Observatory, Photographs of portions of the Moon and of the region surrounding *η Argûs* (enlargements on paper), presented by Mr. H. C. Russell; Astronomische Gesellschaft, Catalog, Zone + 50° bis 55° (Cambridge, Mass.), presented by the Society; Specola Vaticana, Pubblicazioni I. and II., presented by the Observatory; von Kuffner'sche Sternwarte, Publicationen, Band II., presented by the Observatory; J. Bossert, Catalogue de 3950 étoiles (supplément à l'Histoire Céleste de Lalande), presented by the author.

On the Variation of Latitude, as indicated by Recent Observations at the Royal Observatory, Greenwich. By W. G. Thackeray and H. H. Turner, M.A., B.Sc.

The publication of a Star Catalogue at Greenwich has generally been an occasion for discussing the systematic errors of that and of previous catalogues, from comparisons *inter se*, or with catalogues of other observatories. The last Greenwich Catalogue (Ten-Year, 1880) is, for instance, readily comparable with Stone's Cape Catalogue, 1880, and the comparison has an important bearing on the determination of refraction. It has, indeed, already been made, but the discussion is not quite complete, though it is hoped soon to publish the results. But a somewhat new departure has been made in connection with the Ten-Year Catalogue, in the comparison of the N.P.D.s for different years with the mean. The investigation was, from the nature of the case, limited to those stars which had been well observed at different epochs throughout the ten years; and in practice only those stars were included which had been observed in at least five years out of the ten. For such stars the annual means for N.P.D., formed in the computation sheets during the process of reduction to 1880·0, were compared with the finally adopted result for N P.D., and the excesses tabulated under the respective years, with a view to the detection of systematic error. Subsidiary arrangements of these quantities were made both in R.A. and N.P.D., and the results are shown in the following tables.

TABLE I.

Excess of Annual Mean N.P.D. over Adopted Result for N.P.D., arranged according to Right Ascension.
(The suffixes indicate the number of observations.)

R.A. h h	1877.	1878.	1879	1880.	1881.	1882.	1883.	1884.	1885.	1886.
0 – 6	$+0''.03_{385}$	$+0''.09_{393}$	$+0''.07_{291}$	$+0''.01_{471}$	$-0''.06_{171}$	$-0''.04_{130}$	$+0''.06_{111}$	$-0''.26_{126}$	$+0''.04_{180}$	$-0''.01_{493}$
6 – 12	$-0''.02_{241}$	$-0''.02_{317}$	$+0''.09_{247}$	$-0''.04_{315}$	$+0''.06_{278}$	$+0''.09_{122}$	$+0''.04_{281}$	$+0''.01_{314}$	$-0''.08_{215}$	$+0''.01_{371}$
12 – 18	$+0''.10_{269}$	$+0''.04_{316}$	$-0''.09_{225}$	$-0''.13_{240}$	$+0''.06_{278}$	$+0''.05_{120}$	$+0''.17_{200}$	$+0''.02_{205}$	$-0''.13_{244}$	$-0''.06_{222}$
18 – 24	$+0''.11_{472}$	$+0''.12_{423}$	$+0''.01_{317}$	$-0''.16_{314}$	$-0''.11_{160}$	$-0''.03_{112}$	$+0''.02_{250}$	$+0''.09_{344}$	$-0''.09_{260}$	$-0''.05_{406}$
Mean	$+0''.06_{1373}$	$+0''.06_{1541}$	$+0''.02_{1403}$	$-0''.08_{1600}$	$-0''.03_{1647}$	$+0''.02_{1503}$	$+0''.06_{1642}$	$+0''.02_{1500}$	$-0''.06_{1569}$	$-0''.03_{1670}$

Table II.

Excess of Annual Mean N.P.D. over Adopted Result for N.P.D., arranged according to N.P.D.

(*The suffixes indicate the number of observations.*)

N.P.D.		1877.	1878.	1879	1880.	1881.	1882.	1883.	1884.	1885.	1886.
− 30 to − 40		−0″.59$_{6}$	...	+0″.36$_{3}$	−0″.27$_{7}$	+0″.21$_{7}$	−0″.17$_{11}$	+0″.02$_{12}$	+0″.39$_{14}$	−1″.04$_{1}$	−0″.25$_{8}$
− 20	− 30	−0.47$_{6}$	−0.12$_{5}$	−0.27$_{7}$	−0.14$_{19}$	+0.12$_{18}$	−0.26$_{13}$	+0.11$_{16}$	−0.14$_{13}$	−0.03$_{61}$	+0.20$_{59}$
− 10	− 20	−0.08$_{12}$	+0.29$_{7}$	+0.11$_{10}$	−0.04$_{12}$	−0.01$_{12}$	−0.07$_{22}$	−0.09$_{39}$	−0.01$_{10}$	−0.02$_{37}$	−0.14$_{28}$
− 0	− 10	−0.06$_{162}$	−0.13$_{109}$	−0.35$_{97}$	−0.23$_{110}$	−0.02$_{161}$	+0.03$_{169}$	+0.24$_{200}$	+0.31$_{188}$	−0.14$_{153}$	+0.12$_{124}$
0	10	+0.07$_{200}$	+0.08$_{110}$	+0.09$_{140}$	−0.11$_{192}$	−0.09$_{183}$	−0.05$_{206}$	+0.19$_{210}$	+0.12$_{181}$	−0.22$_{178}$	−0.11$_{163}$
10	20	+0.18$_{77}$	0.00$_{92}$	−0.13$_{80}$	+0.03$_{94}$	−0.08$_{74}$	−0.06$_{13}$	+0.01$_{17}$	+0.15$_{57}$	−0.11$_{57}$	+0.02$_{62}$
20	30	+0.05$_{139}$	+0.06$_{110}$	−0.03$_{135}$	−0.15$_{190}$	−0.04$_{200}$	−0.01$_{140}$	+0.11$_{93}$	+0.26$_{92}$	−0.14$_{75}$	+0.08$_{106}$
30	40	−0.19$_{18}$	+0.19$_{23}$	−0.08$_{19}$	−0.13$_{30}$	−0.20$_{21}$	−0.26$_{21}$	+0.18$_{26}$	+0.18$_{23}$	+0.21$_{17}$	+0.08$_{25}$
40	50	+0.01$_{50}$	+0.20$_{31}$	+0.02$_{22}$	−0.04$_{38}$	−0.30$_{11}$	−0.12$_{13}$	+0.03$_{13}$	+0.16$_{30}$	+0.12$_{10}$	−0.15$_{65}$
50	60	+0.02$_{127}$	+0.01$_{133}$	−0.11$_{111}$	−0.12$_{136}$	+0.04$_{111}$	0.00$_{85}$	+0.14$_{77}$	−0.05$_{62}$	+0.02$_{55}$	+0.13$_{19}$
60	70	+0.02$_{221}$	+0.10$_{230}$	+0.06$_{273}$	−0.08$_{299}$	+0.03$_{217}$	−0.03$_{202}$	−0.06$_{167}$	+0.03$_{199}$	−0.03$_{181}$	−0.02$_{231}$
70	80	+0.03$_{161}$	+0.10$_{235}$	−0.10$_{205}$	−0.10$_{214}$	+0.01$_{188}$	+0.06$_{214}$	+0.09$_{196}$	+0.05$_{175}$	−0.03$_{210}$	−0.03$_{186}$
80	90	+0.31$_{85}$	+0.09$_{128}$	−0.02$_{119}$	−0.16$_{110}$	−0.09$_{94}$	+0.17$_{176}$	+0.03$_{174}$	−0.04$_{198}$	−0.17$_{228}$	+0.04$_{246}$
90	100	+0.07$_{51}$	−0.20$_{75}$	+0.08$_{98}$	−0.17$_{108}$	−0.10$_{92}$	+0.09$_{128}$	+0.15$_{191}$	+0.08$_{175}$	−0.10$_{148}$	−0.13$_{186}$
100	110	+0.07$_{55}$	−0.07$_{88}$	+0.02$_{86}$	−0.24$_{75}$	−0.01$_{92}$	+0.01$_{107}$	+0.34$_{111}$	−0.09$_{101}$	−0.22$_{102}$	+0.01$_{87}$
110	120	−0.30$_{12}$	+0.05$_{11}$	−0.10$_{55}$	+0.04$_{18}$	+0.54$_{21}$	+0.01$_{77}$	+0.26$_{51}$	−0.02$_{61}$	−0.13$_{39}$	−0.35$_{66}$
Mean	...	+0.06$_{1418}$	+0.06$_{1509}$	+0.01$_{1514}$	−0.08$_{1743}$	−0.02$_{1574}$	+0.02$_{1687}$	+0.07$_{1706}$	+0.01$_{1677}$	−0.07$_{1619}$	−0.04$_{1772}$

It is not proposed to make any further comment on these tables as they stand in the present paper, the object of which is to give the results of a line of investigation suggested by the inspection of Table I., which affords sufficient evidence in favour of Mr. Chandler's fourteen-monthly period in latitude to make the present note of immediate interest.

Mr. Thackeray's interpretation of Table I. was as follows:—The right ascension of a star is a rough indication of the time of year at which it was observed. We may assume the mean time of observation at Greenwich to be about midway between sunset and 2 A.M., or for our present purpose 10 o'clock P.M.; so that the mean time of observation of the groups 0^h–6^h, 6^h–12^h, 12^h–18^h, and 18^h–24^h would be as follows:—

Group.	Mean R.A.	Mean Epoch of Observation.
h h	h	
0–6	3·0	Dec. 5
6–12	9·0	Mar. 7
12–18	15·0	June 6
18–24	21·0	Sept. 5

If, then, the groups in Table I. are arranged consecutively, placing each column in order under the one to the left, we shall have a rough indication of the systematic changes in N.P.D. arranged in order of time. There is, of course, the considerable error in this assumption that observations in the group 0^h–6^h in any year were made partly at the beginning and partly at the end of the year, whereas we can only assign them to one of these epochs; but for the particular discussion in question the error thus introduced is not too serious, for Mr. Chandler's period of variation (fourteen months) does not differ very largely from a year, and consequently the phases at the beginning and end of the year would not be very different.

But it is to be remarked that the formation of such large groups as those of six hours—corresponding to nearly a quarter of the whole period—considerably diminishes the apparent amplitude of the wave under discussion. [The theoretical apparent amplitude would become about seven-tenths of the original.] Further, stars observed below the pole must be regarded as having an R.A. differing by twelve hours from their tabular R.A., and Table I. must be corrected accordingly. The original comparison with Mr. Chandler's inequality was, however, made without this correction.

Crediting the group 0^h–6^h, therefore, to the end of the year, we get the chronological variation of N.P.D., as in the following table in the column O, where in the column C is given the theoretical variation according to Mr. Chandler's paper in the *Astronomical Journal*, No. 267:—

TABLE III.

Excess of Mean Annual Mean N.P.D. over Adopted Result for N.P.D., arranged for every 6h of Right Ascension and compared with the Theoretical Variation of Latitude computed from Chandler's Formula ("Astronomical Journal," No. 267).

Date.	O.	C.	Date.	O.	C.
1877 Mar. 7	$-0\cdot02_{215}$	− ·01	1882 Mar. 7	$+0\cdot08_{466}$	+ ·22
June 6	$+0\cdot10_{254}$	+ ·21	June 6	$+0\cdot01_{410}$	+ ·04
Sept. 5	$-0\cdot13_{188}$	+ ·09	Sept. 5	$0\cdot00_{229}$	− ·19
Dec. 5	$+0\cdot02_{268}$	− ·17	Dec. 5	$-0\cdot03_{240}$	− ·14
1878 Mar. 7	$+0\,01_{315}$	− ·15	1883 Mar. 7	$+0\cdot05_{337}$	+ ·11
June 6	$+0\cdot04_{268}$	+ ·11	June 6	$+0\cdot09_{375}$	+ ·20
Sept 5	$+0\cdot10_{466}$	+ ·20	Sept. 5	$+0\cdot01_{372}$	0·00
Dec. 5	$+0\cdot08_{290}$	·00	Dec. 5	$+0\cdot13_{339}$	− ·20
1879 Mar. 7	$+0\cdot04_{288}$	− ·22	1884 Mar. 7	$+0\cdot01_{287}$	− ·07
June 6	$+0\,03_{288}$	+ ·09	June 6	$-0\cdot10_{401}$	+ ·15
Sept. 5	$+0\,01_{319}$	+ ·17	Sept. 5	$+0\cdot07_{371}$	+ ·18
Dec. 5	$+0.03_{311}$	+ ·15	Dec. 5	$+0\cdot05_{282}$	− ·06
1880 Mar. 7	$-0\cdot05_{238}$	+ ·09	1885 Mar. 7	$-0\cdot09_{344}$	− ·22
June 6	$-0\cdot08_{401}$	−0·22	June 6	$-0\cdot03_{114}$	− ·07
Sept. 5	$-0\cdot14_{435}$	0·00	Sept. 5	$-0\cdot08_{498}$	+ ·19
Dec. 5	$-0\cdot04_{469}$	+ ·21	Dec. 5	$-0\cdot06_{310}$	+ ·13
1881 Mar. 7	$+0\cdot07_{228}$	+ ·11	1886 Mar. 7	$+0\cdot03_{236}$	− ·11
June 6	$+0\cdot05_{280}$	− ·15	June 6	$-0\,05_{317}$	− ·20
Sept. 5	$-0\cdot13_{171}$	− ·20	Sept. 5	$-0\cdot06_{530}$	·00
Dec. 5	$-0\cdot06_{290}$	+ ·04	Dec. 5	$-0\cdot03_{116}$	+ ·19

This comparison is professedly only rough; but, as it is distinctly favourable to the existence of an inequality such as that of Mr. Chandler's (more especially noticeable when the results are represented in diagrammatic form), a more direct investigation was at once undertaken. A complete examination of all the stars would have involved much labour, and it was, therefore, determined to make some preliminary calculations before definitely embarking on this enterprise.

I. From the theoretical expressions given in Mr. Chandler's paper, above quoted, the epochs of maximum and minimum latitude were calculated. Now, it has long been recognised that there are systematic errors of *annual* period affecting the Greenwich N.P.D.s, the origin of which is not yet completely understood, but which it is necessary to eliminate carefully for the purposes of the present discussion. This can be done by comparing observations of the same star made (say) in 1880

December and 1883 December, when the phase of the annual inequality should be the same, but that of Mr. Chandler's inequality should be a maximum in one case and a minimum in the other. Accordingly search was made for observations of the same stars, in months of the same name, at two epochs when such observations should be in one case on the crest, in the other in the trough of Mr. Chandler's wave, and the mean differences formed, weights being assigned according to the formula $\frac{2mn}{m+n}$, where m and n are the numbers of observations at the two epochs. The results, with corresponding weights, are given in Table IV.

The material available must now be restricted to 1880 and following years, for there are systematic corrections to be applied to the individual results in 1877–1879, though these corrections were applied in the Ten-Year Catalogue.

TABLE IV.

Epochs of Maximum.	Minimum.	Diff.	Weight.
1883 May 20	1880 May 23	−0′62	51
1880 Dec. 26	1883 Dec. 19	−0·05	48
1884 July 27	1881 July 31	−0·69	39
1882 Mar. 3	1885 Mar. 4	−0·27	230
1885 Oct. 11	1882 Oct. 8	−0·18	87
1883 May 20	1886 May 19	−0·44	120
1886 Dec. 28	1883 Dec. 19	−0·60	38
1884 July 27	1887 Aug. 8	−0·82	76
1888 Mar. 10	1885 Mar. 4	+0·16	60
1885 Oct. 11	1888 Oct. 29	−0·46	89
1889 June 12	1886 May 19	−0·20	122
1886 Dec. 28	1890 Jan. 21	−0·40	79
	Mean ...	−0·35	

The sign − implies that the differences of the observed N.P.D.s are too large, or, according to Chandler, that at the period of maximum the mean colatitude is too large, and at the period of minimum the mean colatitude is too small.

II. So far the theoretical difference between the epochs of maximum and minimum is very fairly confirmed, though it is obvious that there are large accidental errors. As a further and independent test, the epochs were selected where the wave crosses the zero line; but there are of course ascending nodes and descending nodes, and comparisons were made between nodes of opposite senses, and not those of the same sense. The

results, as will be seen from Table V., were not so favourable to the theory, which may be due to one of three causes—

(1) The large accidental errors, in which are to be included systematic errors of a different kind from the one here considered. It will be shown, for instance, in the sequel that there is evidence of a 5-yearly inequality.

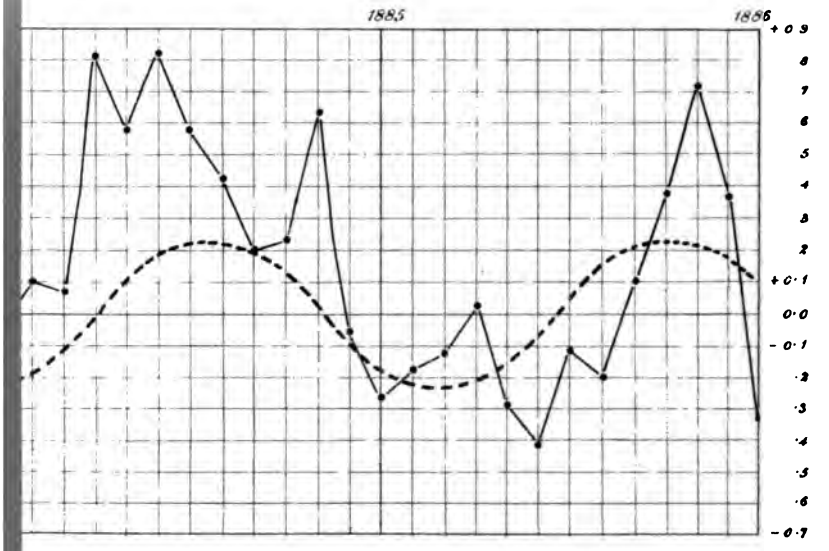
(2) A slight error in the epoch of the inequality, owing to which the wave is displaced in the direction of its length. The results of Table IV. would in this case not be appreciably affected; but there would be the maximum disturbance of Table V. It would appear from the sequel that the error, if any, is small.

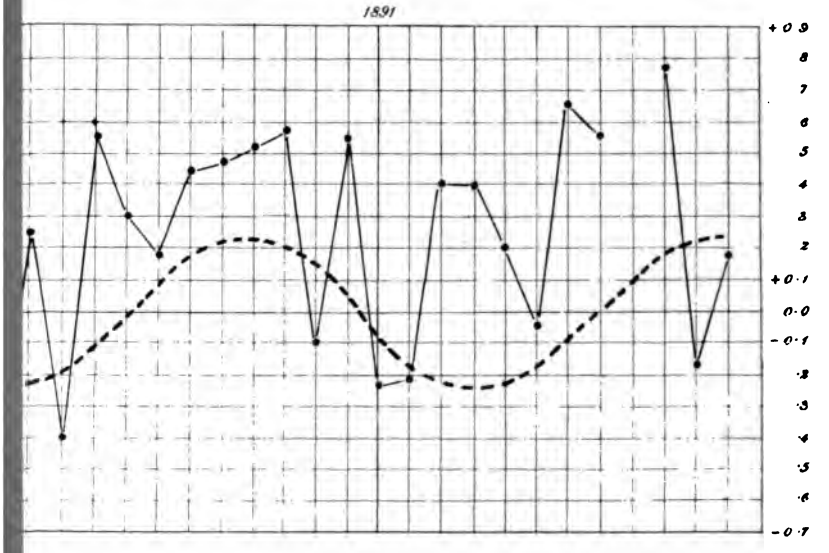
(3) A want of symmetry in the wave, owing to the rotation of the pole being elliptic and not circular. It is evident from the sequel that this is very doubtful, but combined with (1) might be the explanation of the persistence of sign in Table V.

TABLE V.

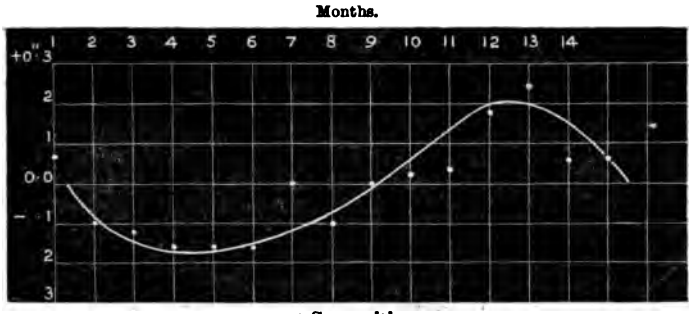
Epochs of Zero.	Zero.	Diff.	Weight.
1883 Sept. 5	1880 Sept. 9	−0·74	106
1881 April 14	1884 April 8	−0 13	120
1884 Nov. 14	1881 Nov. 16	−0·16	74
1882 June 21	1885 June 24	−0 11	127
1886 Jan. 29	1883 Jan. 28	+0 24	101
1883 Sept. 5	1886 Sept. 8	−0·07	168
1887 April 19	1884 April 8	+0·06	99
1884 Nov. 14	1887 Nov. 25	−0·26	138
1888 July 5	1885 June 24	−0·15	85
1886 Jan. 29	1889 Feb. 19	+0·29	53
1889 Oct. 1	1886 Sept. 8	−0·22	114
	Mean ...	−0·14	

III. The most satisfactory material for such a discussion as the present is obviously the series of observations of the close circumpolars, and especially *Polaris*, which extend over many months, and are otherwise numerous, and were accordingly excluded from discussions I. and II., to be treated independently. A treatment of these precisely similar to that in discussions I. and II. need not be further considered here, as it is virtually included in the final discussion; wherein monthly means uncorrected for R − D were formed from the observations of these stars in the years 1880–1891, and compared with an adopted mean place for 1885·0, obtained by combining the places in the Ten-Year Catalogue 1880·0 and the Five-Year Catalogue 1890·0 (shortly to be published), and the differences plotted on paper as


1885
1886
+0·9
8
7
6
5
4
3
2
+0·1
0·0
-0·1
·2
·3
·4
·5
·6
-0·7

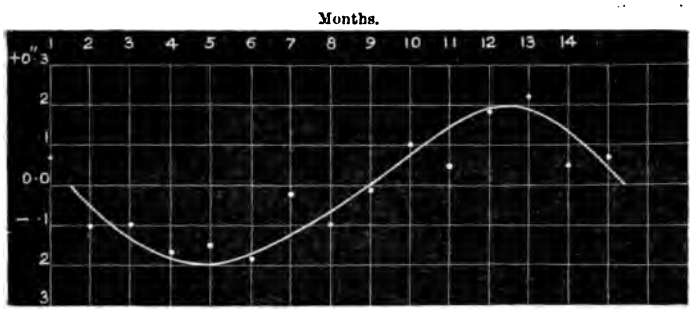

1891
+0·9
8
7
6
5
4
3
2
+0·1
0·0
-0·1
·2
·3
·4
·5
·6
-0·7

in Plate I, on which is also shown Mr. Chandler's theoretical curve. It will be seen that there is a fair agreement



1st Supposition.

almost throughout, although there are three marked divergences between the two which do not seem to be wholly explicable by



1st Supposition (corrected).

accidental error. These occur about 1881, 1886, and 1891, and the equality of the intervals separating them suggests a five-yearly disturbance, as mentioned above, though the evidence is, of course, very incomplete.

But when corresponding phases of the wave are taken together and the mean result formed for the whole of the nine periods, there seems to be indisputable evidence of the Chandler wave. There is a little doubt occasionally as to the assignment of particular months which fall between two of the fourteen or fifteen phases of the wave; but, adopting the two different suppositions of a fourteen- or fifteen-month period as roughly agreeing with the varying periods of rotation at the beginning of 1880 and end of 1890 respectively, the observations give the results shown in Table VI.

The results of columns 2 and 4 have been corrected for the general mean correction +0″·12.

The 3rd and 5th columns have been corrected as follows:— It has been assumed that the R – D correction varies annually

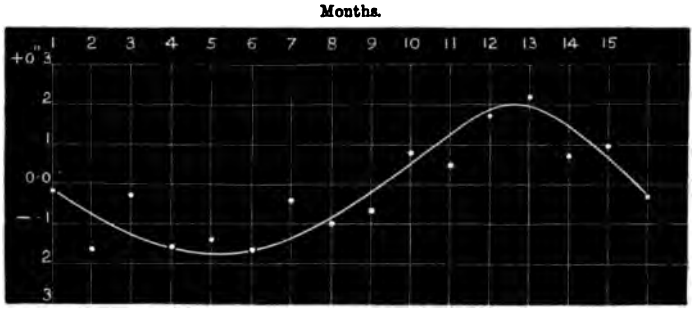
about a constant mean value during the period under discussion, and that the mean for the four polars above and below pole is $-0''.35$. The value of the correction for the different months has been computed from the coefficients given by Mr. Turner in his paper communicated to the Society in March last, and the following corrections for the differences between these values and the mean have been applied.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
$+''.05$	$+''.07$	$+''.01$	$-''.06$	$-''.15$	$-''.14$	$-''.10$	$-''.05$	$-''.01$	$-''.02$	$+''.02$	$+''.03$

The general mean correction of $+0''.09$ has also been applied. The wave form given by the corrected results appears to be the more symmetrical.

TABLE VI.

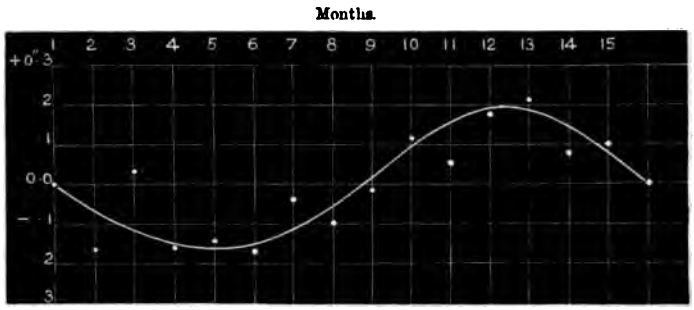
Phase.	1st Supposition.	1st Supposition. Corrected for R–D.	2nd Supposition.	2nd Supposition. Corrected for R–D.
1st month	$+0''.07_{246}$	$+0''.09$	$-0''.01_{229}$	$0''.00$
2nd ,,	$-0''.10_{221}$	$-0''.10$	$-0''.17_{218}$	$-0''.16$
3rd ,,	$-0''.11_{234}$	$-0''.10$	$-0''.02_{174}$	$+0''.03$
4th ,,	$-0''.16_{238}$	$-0''.17$	$-0''.15_{215}$	$-0''.16$
5th ,,	$-0''.15_{228}$	$-0''.14$	$-0''.13_{229}$	$-0''.14$
6th ,,	$-0''.15_{232}$	$-0''.18$	$-0''.16_{224}$	$-0''.16$
7th ,,	$0''.00_{239}$	$-0''.02$	$-0''.04_{215}$	$-0''.03$
8th ,,	$-0''.10_{217}$	$-0''.10$	$-0''.10_{217}$	$-0''.10$
9th ,,	$0''.00_{221}$	$-0''.01$	$-0''.07_{221}$	$-0''.01$
10th ,,	$+0''.02_{217}$	$+0''.10$	$+0''.09_{217}$	$+0''.11$
11th ,,	$+0''.04_{196}$	$+0''.05$	$+0''.05_{188}$	$+0''.07$
12th ,,	$+0''.19_{276}$	$+0''.19$	$+0''.19_{276}$	$+0''.18$
13th ,,	$+0''.26_{234}$	$+0''.23$	$+0''.21_{215}$	$+0''.21$
14th ,,	$+0''.07_{276}$	$+0''.06$	$+0''.09_{111}$	$+0''.09$
15th ,,	...	...	$+0''.10_{216}$	$+0''.10$



2nd Supposition.

The 2nd supposition especially, and to some extent the 1st, shows something of a want of symmetry in the wave, which

is more or less removed by the application of the correction for an assumed monthly difference in the R—D correction, and



2nd Supposition (corrected).

further evidence is needed to confirm this. The investigation will be continued, and the present paper must be regarded as preliminary merely; but the matter is of sufficient importance to make it advisable to publish these results at once.

On the Systematic Errors of the Moon in Right Ascension.

By H. H. Turner, M.A., B.Sc.

In February 1892 Captain Grant, of the Ordnance Survey, consulted the Astronomer Royal concerning operations for fixing the boundary of Mashonaland, in concert with Portuguese officers, by parallels of latitude and longitude.

It was decided that he should determine the requisite longitudes by Moon-culminations, taking with him a portable transit by Troughton & Simms. Application has several times been made to the Astronomer Royal, in connection with similar operations, for a list of the Moon's errors on certain dates, as determined by the Greenwich Transit Circle, but in the present instance the actual landmarks were to be fixed on the spot, and hence retrospective corrections depending on information supplied from Greenwich were out of the question. It remained to be decided whether from recent observations any prospective corrections to the Moon's place could be tabulated and furnished to Captain Grant before his departure. For this purpose a complete list of observed errors of the Moon in R.A. for the years 1883–1891 was formed. The year 1883 was the first in which Newcomb's corrections to Hansen's tables were applied in the *Nautical Almanac*; and quite apart from any theoretical question as to the exact relation of these corrections to Hansen's tables, their adoption in the *Nautical Almanac* has had the advantage of bringing readily into prominence several features of the residuals previously masked by the large corrections which had been

required by those tables. As an example, I may quote the annual mean error in R.A. of the Moon, given in the annual reports of the Astronomer Royal to the Society, or to the Board of Visitors. The latter value, computed in May, which sometimes differs slightly from the former, computed in February, is to be preferred; for by May the observations of the previous year have been examined more thoroughly, and numerical errors, if any, corrected. The following is a list of such annual means:—

	Report to R.A.S.	Report to B. of V.		Report to R.A.S.	Report to B. of V.
	s	s		s	s
1883	+0·032	+0·031	1888	+0·079	+0·090
1884	+0·021	+0·018	1889	+0·010	+0·010
1885	+0·028	+0·024	1890	+0·020	−0·020
1886	+0·029	+0·029	1891	+0·079	+0·077
1887	+0·068	+0·059	Mean	+0·041	+0·040

The persistently positive sign of this quantity is noteworthy; and it is quite possible that the departures from the mean value may be accidental.

Again, there is a persistent difference, as will appear presently, between the errors before and after Full Moon, which may apparently be predicted empirically without making any attempt to refer it to one of several possible causes.

The aforesaid errors for 1883–1891 were arranged so that corresponding lunations in each year (the correspondence being, of course, only approximate) and corresponding days in each lunation (reckoning from Full Moon) were taken together. There were naturally many gaps in each lunation—days on which no meridian observation had been obtained at Greenwich—but from the data available an attempt was made to estimate the mean error on five dates in each lunation—viz. nine days before Full Moon, five days before, Full Moon, five days after, and nine days after. This was done for the mean January lunation, the mean February lunation, &c.; that is all the lunations where the Full Moon fell in January were considered "corresponding" and taken together, as remarked above; and if there had been an observation on every day, we should have had forty-five errors of which to take the mean to obtain the mean error at Full Moon in January—viz. a set of five days in each year comprising Full Moon and two days each side; and similarly for the other epochs. As a matter of fact, instead of forty-five errors there were generally only about fifteen, and hence came considerable uncertainty in estimating correctly.

The first point noticed from the results of this work was that the errors after the Full were algebraically greater than those

before. Further, that this difference was more marked in the summer than in the winter months. By a graphical process the following mean differences were deduced between the errors before and after Full, a positive sign indicating that the error after the Full is greater than that before:—

	s		s
Jan.	+0·04	July	+0·17
Feb.	+0·11	Aug.	+0·13
Mar.	+0·16	Sept.	+0·07
Apr.	+0·20	Oct.	+0·01
May	+0·21	Nov.	−0·02
June	+0·20	Dec.	+0·02

The change at Full has been treated for simplicity as a discontinuity and not as a progressive change. The whole process being, in fact, of a tentative character, it is not advisable to give figures in greater detail; but it may be remarked that the adoption of an erroneous semi-diameter is a possible explanation of this phenomenon; for errors after the Full are deduced from observations of the second limb only, and before from those of the first. Now, if the adopted semi-diameter is too large, too large a quantity will be subtracted from transits after the Full; the observed "transit of centre" will be too small, and the error of the tables consequently a positive quantity; while before the Full the reverse is the case. Again, the adopted semi-diameter may be large owing to the spurious border, due to irradiation, which surrounds the limb of the Moon, and has been recognised as explaining "projection" in occultations of bright stars, and which would be most emphatic at midnight, the time of transit of Full Moon, when the diameter is usually measured with meridian instruments; whereas at the transits of First and Last Quarter Moons the irradiation border would be lost in the twilight background; and this would be especially the case in the summer. If this explanation be the true one, then the use of errors obtained by a large instrument for correction of those with a small is of somewhat doubtful expediency.

Next it was noticed that, considering the mean errors on any given date (nine days before Full, five days before, &c.) in, say, a January lunation, there was a certain progression from year to year; and it was hoped that by plotting these errors as ordinates against the years as abscissæ, a curve might be obtained sufficiently definite to allow of extension for one year, and hence the approximate error on this date for January 1893, &c. might be predicted. The great drawback to the method is the number of gaps in the different series; and as a first attempt two or three years were taken together to remedy this defect. The

resulting predictions for January and February 1893 were compared with the actual observations which were already available, and it was seen that no great measure of success had been attained. A second attempt was then made by first filling up the gaps by estimation from neighbouring dates, and the results of this attempt were more satisfactory, and were adopted for use.

Since the subjoined table was furnished to Captain Grant, the Moon has now been observed throughout the period under consideration, and it may, therefore, interest the Fellows of the Society to note the measure of success attained by a purely empirical method in a case of this kind. From what has been said above, it will be clear that this note is in no way intended as a serious contribution to lunar theory.

It will be seen that predictions were not made for the earlier days in each lunation, though the observations with the Transit Circle are printed.

Corrections to R.A. of Moon in 1892. *Predicted approximately from the errors* 1883—1891 *in Transit Circle Observations at Royal Observatory, Greenwich.*

	Pred.	Obs.	O−P
	s	s	s
May 3	+0·14	...	...
4	+0·12	...	...
5	+0·11	...	...
6	+0·09	+0·15	+0·06
7	+0·08	...	...
8	+0·07	−0·05	−0·12
9	+0·05	+0·16	+0·11
10	+0·03	+0·10	+0·07
11	0·00	−0·09	−0·09
12	−0·04	−0·10	−0·06
13	−0·10	...	...
14	−0·15	−0·02	+0·13
15	−0·19	−0·20	−0·01
16	−0·23	...	...
17	−0·27	...	...
18	−0·30	−0·13	+0·17
Numerical Sum ...		1·00	0·82

	Pred.	Obs.	O−P
	s	s	s
May 30	...	−0·08	...
June 1	...	+0·07	...
2	..	+0·07	...
3	+0·19	...	...
4	+0·16	...	...
5	+0·09	−0·01	−0 10
6	+0·02	...	...
7	−0·05	−0·04	+0·01
8	−0·08	−0·11	−0·03
9	−0·10	−0·06	+0·04
10	−0·13	−0·02	+0·11
11	−0 17	...	...
12	−0·21	−0·25	−0·04
13	−0·25	...	...
14	−0·28	...	...
15	−0·31	...	...
16	−0·33	...	...
17	−0·35	−0·40	−0·05
Numerical Sum	...	0·89	0·38

	Pred.	Obs.	O−P
	s	s	s
July 2	+0·12	+0·11	−0·01
3	+0·07	−0·04	−0·11
4	+0·01	+0·02	+0·01
5	−0 04	...	...
6	−0·09	...	...
7	−0·12	+0·09	+0·21
8	−0 13	−0·03	+0·10
9	−0 15	−0·21	−0·06
10	−0·19	−0·36	−0·17
11	−0·24	...	...
12	−0·28	...	...
13	−0·29	...	...
14	−0·29	...	...
15	−0 30	...	...
16	−0·30	...	...
Numerical Sum	...	0·86	0·67

	Pred.	Obs.	O−P
	s	s	s
July 28	...	+0·14	...
29	...	+0·10	...
30	...	+0·11	...
31	+0·10	...	...
Aug. 1	+0·06	...	...
2	+0·01	...	...
3	−0·04	...	...
4	−0·08	+0·17	+0·25
5	−0·11	...	...
6	−0·13	+0·11	+0 24
7	−0·15	...	...
8	−0 15	...	...
9	−0·16	...	...
10	−0·16	−0 52	−0·36
11	−0·17	−0·40	−0·23
12	−0·17	−0·41	−0·24
13	−0·18	−0·49	−0·31
14	−0·18	−0·46	−0 28
15	−0·17	−0·42	−0 25
16	...	−0·39	...
Numerical Sum	...	2·98	2·16

	Pred.	Obs.	O−P
	s	s	s
Aug. 26	+	+0·17	...
27	...	...	...
28	...	+0·14	...
29	...	...	...
30	+0·16	+0·21	+0·05
31	+0·16	...	...
Sept. 1	+0·14	−0·06	−0·20
2	+0·12	...	...
3	+0·09	+0·16	+0·07
4	+0·04	−0·13	−0·17
5	−0·02	−0·19	−0·17
6	−0·06	−0·22	−0·16
7	−0·10	−0·26	−0·16
8	−0·13	−0·37	−0·24
9	−0·16	...	...
10	−0·16	−0·38	−0·22
11	−0·15	−0·38	−0·23
12	−0·14	...	...
13	...	−0·45	...
Numerical Sum	...	2·36	1·07

Corrections to Hansen's Tables de la Lune. By James Gordon.

(*Communicated by the Rev. S. J. Johnson, M.A.*)

I have reviewed Professor Newcomb's "Researches on the Motion of the Moon," part 1, and I have accepted his graphical interpolation of the individual corrections to the Moon's mean longitude for intervals of a quarter of a century. I then throughout gave each equation of condition the weight of unity, as I look with suspicion on assigning different weights to the observations. I took out from the theory all of Hansen's terms of long period due to the action of the planets on the Moon, and substituted an inequality of long period, which goes through precisely the same changes in 2831 years, and is made up of the two composite periods of $257\frac{4}{11}$ years and 149 years respectively. This inequality depends upon the distance of the Moon from the plane of the Sun's equator, when the Moon arrives at conjunction with the Sun. The following is the correction to the Moon's mean longitude which I have determined :—

$$\delta\epsilon = \delta v + \delta nz.$$

In which

$$\delta v = +0''{\cdot}23 - 29''{\cdot}35\ T - 3{\cdot}976\ T^2.$$

And

$$\delta nz = -(V_1 + V_2 + M) + (14''{\cdot}1 \sin A + 0''{\cdot}9 \sin A')$$

in which T is the number of centuries from the epoch of Hansen's Tables, viz.: January 0·0 1800; δv is the correction to the Moon's true longitude, and δnz to that of the fundamental argument. The terms V_1, V_2, and M are the values assigned by Hansen in the respective tables, xlii., xli., and xl., with the arguments 31, 30, and 29. The outstanding residuals are as follows:—

1625	+2·1	1725	−1·4	1825	−0·2
1650	−2·4	1750	−1·4	1850	+0·8
1675	−0·4	1775	+1·0	1875	−0·5
1700	+0·1	1800	+0·7		

I have calculated a table at five-years intervals between A D 1600 and A D 2000 inclusive; of the values of $\delta\epsilon$, which represents the correction to the Moon's mean longitude; and it is a well-known fact that Hansen, being unable to determine the coefficients of his *Venus* terms, from theory, assigned such values to them as brought observation and theory into agreement during the period 1750–1850, but this he only attained by sacrificing accuracy before and after this interval. Now, if my corrections to the Moon's mean longitude are well founded, they ought to

approach zero during the above interval. The following table gives the correction $\delta\epsilon$ for the interval 1750–1850:—

Epoch.	Corr.	Epoch.	Corr.	Epoch.	Corr.
1750	+1″·5	1785	−0″·9	1820	+0″·3
1755	+1·1	1790	−1·3	1825	0·0
1760	0·0	1795	−1·3	1830	+0·5
1765	−0·7	1800	−0·5	1835	+0·6
1770	−0·5	1805	−0·6	1840	0·0
1775	−1·0	1810	−0·6	1845	−0·2
1780	−1·8	1815	−0·1	1850	−0·4

I then made a selection of 105 of the best of the equations of condition formed from the occultation of stars given in Professor Newcomb's "Researches on the Motion of the Moon." The terms, however, of $\frac{d\mathrm{D}}{de}\delta\epsilon + \frac{d\mathrm{D}}{db_0}\delta b_0 = a$ became known by substituting the value for $\delta\epsilon$ as taken from my table, and for δb_0 I took the mean constant value = + 1″·76 as found for it by Professor Newcomb (see the "Researches," part 1, page 235); this enabled me to bring the equations of condition to the form—

$$\frac{d\mathrm{D}}{ed\varpi}e\delta\varpi + \frac{d\mathrm{D}}{id\theta}i\delta\theta + \frac{d\mathrm{D}}{d\pi}\delta\pi = s' - \mathrm{D} - a.$$

And these I reduced down by least squares in a single group, the resulting normal equations coming out to be as follows:—

$$\begin{array}{llll} +3{\cdot}56\,e\delta\varpi & -0{\cdot}14\,i\delta\theta & -0{\cdot}79\,\delta\pi = & -1''{\cdot}88 \\ -0{\cdot}14 & +0{\cdot}07 & +0{\cdot}03 & = +0{\cdot}45 \\ -0{\cdot}79 & +0{\cdot}03 & +0{\cdot}53 & = +0{\cdot}42 \end{array}$$

the solution of which gives

$$e\delta\varpi = -0''{\cdot}3$$
$$i\delta\theta = +5''{\cdot}83$$

and

$$\delta\pi = \quad 0{\cdot}0$$

As $e = 0{\cdot}055$, and $i = 0{\cdot}0898$, we have for the middle epoch through which the equations extend, viz. A D 1711·6

$$\delta\varpi = -\ 5''{\cdot}4 = \text{Correction to the longitude of perigee.}$$
$$\delta\theta = +64{\cdot}9 = \quad ,, \qquad ,, \qquad ,, \quad \text{node.}$$

While $\delta\pi$, the correction to the Moon's parallax, is zero, or, in other words, Hansen's tables require no correction for this element.

Now, in Professor Newcomb's "Investigation of Corrections to Hansen's Tables de la Lune," 1876, he gives for—

$$1861 \qquad \delta\varpi = +2''.2$$

and

$$1868 \qquad \delta\theta = +4''.5$$

Comparing this with my own determination, I have arrived at the following corrections to the motions of the perigee and node, in which T represents as before the number of centuries from the epoch 1800:—

$$\delta\varpi = -0''.9 + 5''.09\,T$$

and

$$\delta\theta = +30''.75 - 38''.6\,T$$

I have confined myself entirely to modern observations, as the problem of the secular acceleration of the Moon's mean motion is in a very unsettled state. What is aimed at by astronomers is to obtain a constant coefficient progressing according to the square of the time, and this they will never obtain for any great length of time, as the very causes which give rise to this acceleration are not of a constant nature.

Aberlemno, Forfarshire:
1892 *August* 30.

On the Best Form of Mounting for a Large Reflector.

By A. A. Common, LL.D., F.R.S.

A silver on glass mirror of eight or nine feet aperture seems now to be possible, and it becomes worth while to consider the best way to mount such a mirror for astronomical purposes.

Opinions will differ as to the optical arrangements most suitable, but the Newtonian form seems, in my opinion, to be the best, for many reasons that it is not necessary to go into now.

The best use of such an enormous telescope would probably be to explore and discover, and this would naturally be best done by using it as a visual telescope, for which purpose a focal length of about twelve times the aperture would perhaps be most suitable, giving for the smaller mirror above mentioned some ninety-six feet focal length.

To mount such a telescope equatorially and put a dome over it in the usual way would be a most costly undertaking, and even if the money were available it is very doubtful if any form of equatoreal would be the most suitable. The difficulty of providing access to the eye end for the observer, and of following the movement, especially when we remember that off the

meridian the upper part of the tube must be rotated, is one not easily got over.

The equatorial movement is necessary for photographic and spectroscopic work, but here a very much shorter focal length can be advantageously used. For visual work it is undoubtedly the best, but it may be obtained at such a sacrifice of advantages that could otherwise be obtained, that it might be worth while giving up the one for the others.

The chief consideration in designing a mounting for such an immense telescope would be to keep the cost as low as possible; the first thing, therefore, is to give up the equatorial mounting, with its expensive and heavy work, and adopt some kind of altazimuth mounting. We have had large reflectors mounted in this manner. The plan used by Sir William Herschel in mounting his four-foot is typical. For the work of exploration it answers admirably, and the observer is provided with a fairly safe position. There are, however, many objections, such as the close tube, the absence of protection from the wind and rain, and the want of perfect protection and comfort for the observer. Keeping in mind the requirements that experience has shown to be important in designing a reflecting telescope, particularly the use of a skeleton tube instead of a close one, easy access to the mirror for covering or removal, movement in one plane only, &c., and endeavouring to get the very best possible conditions for the observer, I have been led to devise a form of mounting that does certainly offer every advantage that I could wish, excepting that of equatorial motion. The facilities for movement in both directions are so great that I have not any doubt that an apparatus could be designed that would work well enough to keep the object under examination in the field of view in a sufficiently steady manner.

I would take as a basis for the mounting of the telescope that form designed by the late Dr. Draper, and described by him in his paper "On the Construction and Use of a Silvered Glass Telescope," published by the Smithsonian Institution. (The earliest account of a mounting on this principle that I know is in Smyth's *Celestial Cycle*, vol. ii., page 540; this is Miss Herschel's telescope, made probably by Sir William Herschel.) This form of mounting is, no doubt, so well known that it is hardly necessary to do more than mention that the telescope is hung by one end on trunnions, the eye end being in one of them, which is made hollow for the purpose. The counterpoising of the free end of tube with mirror attached is effected by weights carried at the ends of rods supported at their lower ends and connected with the tube by iron wire ropes. The square framework carrying the tube and counterpoises revolves on a central pin, so the eye end is carried round in a circle of about the diameter of the focal length. I would use such a framework as this, but double the length, with the telescope in one half and the counterpoise weights in the other. The centre

of motion I would place exactly under and midway between the trunnions, the eye-piece end being about five feet from the centre of motion, causing a necessary movement of the observer of at the most 30 inches per hour.

Instead of a tube connecting the mirrors it would only be necessary to have two lattice girders braced together at the top and bottom. For a few feet near the trunnions a tube would be needed, but instead of putting any more tube I would enclose the framework containing the mirrors entirely, making it a large dark chamber, the connection being made at the trunnion end by a flexible material.

The square framework carrying the dark chamber which forms the telescope and the counterpoise weights in the other side would rotate on a central vertical pin, the greater part of the weight being taken off by floating a suitable circular tank in water; the mirror end of the two lattice girders could slide along an arc of a circle, so that by suitable gearing an end movement could be given in altitude, a similar movement in azimuth being obtained at the edge of the circular tank. We should thus have a complete telescope capable of being pointed to any part of the heavens.

To shelter this from the wind and weather, and to support the observer, I would enclose the whole in a framework covered with any suitable material, and of such a shape as to come close up to the upper end of the tube near the trunnions, where the chamber in which the observer could sit, would be placed. The whole of this outer framework would run on a circular railway, and could be made sufficiently wide to provide for two or three hours' continuous movement of the contained telescope without any alterations, the only opening being a flap shutter at an angle of 45°, covering the open end of the telescope when not in use.

Access would be obtained for the observers by suitable stairs on the outer framework, which, being entirely detached from the inner telescope, would not affect it.

There are many matters of detail which would have to be worked out, but it will be found that the form of mounting I have indicated here is one that offers many advantages, particularly as regards the question of cost, while it provides for the safety and comfort of the observer absolutely.

There are two modifications in this form that are worth consideration—the first, that the second part of the frame carrying the counterpoise weights in the above-mentioned plan might be dispensed with, as well as the covering of inner framework, counterpoising it by weights in the floating tank. This would reduce by nearly one-half the size of the outer covering, but it would be attended with this disadvantage: the wind would have enormous power in the outer covering, as the centre of rotation would be near one end. The other modification is to have the framework containing the telescope rotating exactly on the same plan as Dr. Draper's, and enclose the whole in a fixed circular house

similar to his, with a provision for carrying the observer similar in general character to his, making it, in fact, exactly on the lines he has laid down.

The first modification would, perhaps, be the best form altogether, as the sides and ends of the outer house could be made with a considerable slope, so as to reduce the upsetting power of the wind. This would retain the important position of the observer as close as possible to the centre of motion of the telescope.

Probable Error of the Clock Correction when both the Clock Rate and the Instrumental Constants are found by a Least Squares Solution of a Single Night's Observations. By the Rev. John T. Hedrick, S.J.

(*Communicated by the Rev. W. Sidgreaves, S.J.*)

It seems to be a common practice in the comparison of time determinations, as in longitude work, to give a constant probable error for the clock correction of each night and to combine the different nights' work according to these probable errors. This is equivalent to taking the clock rate as known perfectly, whereas its value has also its degree of uncertainty, making the probable error of the clock correction quite different for different moments. Of course, if the time comparison takes place during the period of observation, and especially if about its middle, there will be less objection to the method.

A reason for this neglect of the probable error of the clock rate may be the difficulty of determining it when another quite common practice is followed of determining the clock rate from the comparison of the clock corrections found from night to night. If results are expected of sufficient accuracy to make it worth while taking account of probable errors, this practice seems hardly defensible for observations made with portable instruments. For we are likely to have periodic or irregular fluctuations of rate in a clock, not of the best, exposed to receiving injurious shocks in carriage, and not set up so as to be thoroughly protected against the effects of change of temperature, or even against instability in the clock pier. Whatever periodic or accidental errors may exist in the star places of the various modern ephemerides, they are so small that, except in a fixed observatory, the proper method is to find the clock rate each night from that night's observations.

Supposing that a least squares solution of the night's work is thought worth the while, there is still a difficulty in getting *the general expression for the probable error of the clock correction at any moment.* Its probable error at a given moment may be found by making this moment the epoch of the constant part of the total clock correction; but this may bring in practical diffi-

culties in computing, requiring, for example, the use of more decimal places in the coefficients and logarithms.

Let

ΔT be the clock correction at any moment,
ΔT_0 the clock correction at some assumed moment, and
ρ the clock rate.

From the sum of the squares of the residuals after substitution in the equations of condition of the values found by the least squares solution and the coefficients occurring in the solution, we can find the probable error of ΔT_0 and ρ. The probable error of ΔT will be a function of these probable errors and the interval between the epochs of ΔT and ΔT_0, but it will not be a function of these only, if the proper epoch is not chosen for ΔT_0; for in this case the probable error of ΔT_0 will itself depend on that of the rate. (See equations (2) and (3), below.)

Let

$$n', n'', n''' \ldots .$$

be the known terms of the equations of condition after reduction to weight 1. ΔT_0 and ρ are each determined as a linear function of the ns.

Let

$$\Delta T_0 = \alpha' n' + \alpha'' n'' + \alpha''' n''' + \ldots .$$
$$\rho = \beta' n' + \beta'' n'' + \beta''' n''' + \ldots .$$

where α', β', &c., are functions of the constant coefficients of the equations of condition.

Now

$$\Delta T = \Delta T_0 + t \cdot \rho,$$

where t is the interval between the epochs of ΔT and ΔT_0.

Hence

$$\Delta T = (\alpha' + \beta' \cdot t)n' + (\alpha'' + \beta'' \cdot t)n'' + (\alpha''' + \beta''' \cdot t)n''' + \ldots .$$

Let p be the probable error of an observation of weight 1, and $p\Delta T$, $p\Delta T_0$, and $p\rho$ the probable errors of these quantities. We have (Chauvenet, ii., pp. 498, 499, and 516)—

$$(p\Delta T_0)^2 = p^2 \cdot [\alpha\alpha], \qquad (p\rho)^2 = p^2 \cdot [\beta\beta],$$
$$(p\Delta T)^2 = p^2 \cdot [(\alpha + \beta \cdot t)(\alpha + \beta \cdot t)] = p^2 \cdot ([\alpha\alpha] + 2[\alpha\beta] \cdot t + [\beta\beta] \cdot t^2).$$

From the degree in t of the parenthesis it is evident that there is a value of t which makes $p\Delta T$ a minimum, and but one value. Let us put $\Delta T_{00} = \Delta T$ for this epoch. It is evident also that if the epoch of ΔT_{00} were chosen as the epoch of ΔT_0, we should have $[\alpha\beta] = 0$; for if it is not zero $p\Delta T$ will not be a

minimum for that epoch. Hence, counting t from the epoch of ΔT_{00}—

$$(p\Delta T)^2 = p^2 \cdot ([\alpha\alpha] + [\beta\beta] \cdot t^2) = (p\Delta T_{00})^2 + (p\rho)^2 \cdot t^2 \quad . \quad . \quad . \quad (1)$$

Hence the probable error of ΔT_{00} is independent of that of the rate. If the epoch assumed for ΔT_0 be not that of ΔT_{00}, and t' be the interval between the two epochs,

$$(p\Delta T_0)^2 = (p\Delta T_{00})^2 + (p\rho)^2 \cdot t'^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and

$$(p\Delta T)^2 = (p\Delta T_0)^2 - (p\rho)^2 \cdot t'^2 + (p\rho)^2 \cdot t^2 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

There is no difficulty in assigning the epoch of ΔT_{00} when only it and ρ enter our equations. It is the mean (simple or weighted) of the times of observation. But we have commonly to determine also the azimuth (a), and in the case of a portable instrument the collimation (c) as well, and perhaps the azimuth after reversal (a'). In this case the epoch of ΔT_{00} is not the mean of the times of observation, and it is the object of this note to show *how to find this epoch from the coefficients formed in solving the normal equations for the epoch of* ΔT_0, or to find the quantity t' of equation (2). The probable error of the clock correction at any moment will then be found by (1) or (3).

Since the squares of the probable errors of the quantities found by a least squares solution are inversely proportional to the coefficients each would have in the final equation if it were the first unknown found, it follows that the moment at which the clock correction has the minimum probable error is the moment which, chosen as the epoch from which to compute the coefficients of the rate in the equations of condition, would bring out ΔT_0 in the final equation with the maximum coefficient.

Let us suppose the most general case, namely, that we have to determine a, a', c, ρ, and ΔT_0, and let w = weight. We have this group of five normal equations, using Gauss's notation.

$$[waa]x + [wab]y + [wac]z + [wad]u + [wae]v + [wan] = 0,$$
$$[wab]x + [wbb]y + [wbc]z + [wbd]u + [wbe]v + [wbn] = 0, \text{ \&c.}$$

Let the order of the unknowns and that of their elimination be that given above.

For $[ee \cdot 4]$, the coefficient of $v(\Delta T_0)$ in the final equation, or the quantity to be made a maximum, we have

$$[ee \cdot 4] = [wee] - \frac{[wae]}{[waa]}[wae] - \frac{[be \cdot 1]}{[bb \cdot 1]}[be \cdot 1] - \frac{[ce \cdot 2]}{[cc \cdot 2]}[ce \cdot 2] - \frac{[de \cdot 3]}{[dd \cdot 3]}[de \cdot 3].$$

In the second member all the terms except the last are independent of d, the coefficient of the rate, and hence of the epoch of ΔT_0, and all are positive. Hence $[ee \cdot 4]$ will be a maximum when the epoch is so chosen as to make the last term zero, or, since $[dd \cdot 3]$ is not infinite, when $[de \cdot 3] = 0$.

We have the following expressions, in determinant notation*:—

$$[de\,.\,3] = |[waa][wbb][wcc][wde]| \div |[waa][wbb][wcc]|,$$
$$[ee\,.\,3] = |[waa][wbb][wcc][wee]| \div |[waa][wbb][wcc]|.$$

Or, since e, the coefficient of ΔT_0 in the equations of condition, $=1$—

$$[de\,.\,3] = |[waa][wbb]]wcc][wd]| \div |[waa][wbb][wcc]|,$$
$$[ee\,.\,3] = |[waa][wbb][wcc][w]| \div |[waa][wbb][wcc]|.$$

The only coefficient affected by a change of epoch for ΔT_0 is d, the coefficient of the rate. The denominator of $[de\,.\,3]$ is independent of d, and, as it is not infinite, to make $[de\,.\,3] = 0$ its numerator must become zero. This numerator expressed in the fuller determinant form is—

$$\text{No. of } [de\,.\,3] = \begin{vmatrix} [waa] & [wab] & [wac] & [wad] \\ [wab] & [wbb] & [wbc] & [wbd] \\ [wac] & [wbc] & [wcc] & [wcd] \\ [wa] & [wb] & [wc] & [wd] \end{vmatrix}$$

Let us suppose that we have formed and solved our normal equations with the epoch T for ΔT_0, and let us change the epoch to $T' = T + t'$. The coefficient of the rate is the time of observation minus the epoch of ΔT_0. We shall have the following relations between the two sets of coefficients, d representing in both sets the coefficient of the rate for the epoch T.

Epoch T,	Epoch $T' = T + t'$
d,	$d - t'$,
$[wad]$,	$[wad] - [wa]\,.\,t'$,
$[wbd]$,	$[wbd] - [wb]\,.\,t'$,
$[wcd]$,	$[wcd] - [wc]\,.\,t'$,
$[wd]$,	$[wd] - [w]\,.\,t'$,

* These expressions, as well as those for the other coefficients occurring in the solution of the normal equations (Chauvenet, ii. pp. 531 and 532), can be found by expressing each as a determinant of the second order; *e.g.*

$$[ee\,.\,3] = \frac{1}{[dd\,.\,2]} \times \begin{vmatrix} [dd\,.\,2] & [de\,.\,2] \\ [de\,.\,2] & [ee\,.\,2] \end{vmatrix},$$

substituting in each the determinant expressions for the coefficients of lower order, and applying the theorem

$$\begin{vmatrix} a_{11}a_{21} & \begin{vmatrix} a_{11}a_{31} & \begin{vmatrix} a_{11}a_{41} & \cdots \\ a_{14}a_{44} & \cdots \end{vmatrix} \\ a_{12}a_{22} & a_{13}a_{33} \end{vmatrix} \\ a_{12}a_{22} \end{vmatrix} \begin{matrix} \cdots \\ \cdots \end{matrix} \begin{vmatrix} a_{11} & a_{m1} \\ a_{1m} & a_{mm} \end{vmatrix} = a_{11}^{m-2} \cdot |a_{11}a_{22}a_{33} \ldots a_{mm}|.$$

The first member is the determinant whose element in the kth row and lth column is

$$\begin{vmatrix} a_{11} & a_{(k+1)1} \\ a_{1(l+1)} & a_{(k+1)(l+1)} \end{vmatrix}; \quad k, l = 1, 2, 3 \ldots (m-1).$$

Let us substitute the values for the epoch T′ in the numerator of $[de \cdot 3]$. We have

$$\text{No. of } [de \cdot 3] \text{ for epoch T}' = \begin{vmatrix} [waa][wab][wac][wad]-[wa] \cdot t' \\ [wab][wbb][wbc][wbd]-[wb] \cdot t' \\ [wac][wbc][wcc][wcd]-[wc] \cdot t' \\ [wa]\ [wb]\ [wc]\ [wd]-[w]\ \cdot t' \end{vmatrix}.$$

Splitting up this determinant into two and factoring out t' in the second, we have, for the epoch T′—

$$\text{No. of } [de \cdot 3] = |[waa][wbb][wcc][wd]| - |[waa][wbb][wcc][w]| \cdot t'.$$

Putting this equal to zero and noticing that the first term and the factor of t' in the second term are proportional to $[de \cdot 3]$ for the epoch T and $[ee \cdot 3]$ respectively (4), we find for t' *the interval from the epoch assumed for* ΔT_0 *to that which would give the maximum coefficient for* ΔT_0 *in the final equation, or to the epoch at which the clock correction has the minimum probable error,*

$$t' = \frac{[de \cdot 3] \text{ for the assumed epoch}}{[ee \cdot 3]} \quad \ldots\ldots\ldots \quad (5)$$

The value found for t' is the quotient of the same coefficients, after the equations have been freed from all the unknowns except ΔT_0 and ρ, of which it would have been the quotient, had there been only these two unknowns in the original equations, namely, of the coefficient of ΔT_0 in the normal equation in ρ by that in its own normal equation. It will, in general, differ from $[wde] \div [wee]$ = the mean of the times of observation.

In the example given below the square brackets are used also to indicate the number whose logarithm they enclose.

Summary.

The epoch of the clock correction of maximum weight, or minimum probable error, is not, in general, the mean of the times of observation when, besides the constant clock correction and the clock rate, instrumental constants are also determined from the observations, (5).

If these quantities are found by a least squares solution, this epoch is before or after the epoch assumed for the constant clock correction by an interval which is the quotient of the coefficient of the constant clock correction in the normal equation for the rate by its coefficient in its own normal equation, after the elimination of the other unknowns, (5).

If we count from this epoch, the probable error of the clock correction at any other time is what it would be if the constant correction and the rate were independently observed quantities—

that is, its square is the sum of the square of the probable error at this epoch and the product of the square of the probable error of the rate into the square of the interval from this epoch, (1). Hence the square of the probable error of the clock correction at this epoch is equal to the square of the probable error of the clock correction at the assumed epoch minus the product of the square of the probable error of the rate into the square of the interval between the two epochs.

Example.

Number of stars observed, 20. Number of quantities determined, 5.

Putting v here for the residuals, $[vvv] = 0^s{\cdot}0251$.

For an observation of weight 1, $p^2 = 0^s{\cdot}000761 = [6{\cdot}8815]$.

Mean of the times of observation $= 8^h{\cdot}98$. Assumed epoch of $\Delta T_0 = 9^h{\cdot}0$.

$[ee \,.\, 4] = 3{\cdot}28$, $(p\Delta T_0)^2 = [6{\cdot}8815] \div [0{\cdot}5159] = [6{\cdot}3656] = 0^s{\cdot}000232$.

$[dd \,.\, 4] = 4{\cdot}44$, $(p\rho)^2 = [6{\cdot}8815] \div [0{\cdot}6474] = [6{\cdot}2341] = 0^s{\cdot}000171$.

$[de \,.\, 3] = +5{\cdot}75 = [0{\cdot}7597]$, $[ee \,.\, 3] = +6{\cdot}85 = [0{\cdot}8357]$, $t' = [9{\cdot}9240] = 0^h{\cdot}84$.

Epoch of maximum coefficient $= 9^h{\cdot}84$.

$(p\Delta T_{00})^2 = 0^s{\cdot}000232 - 0^s{\cdot}000171 \,.\, (0{\cdot}84)^2 = 0^s{\cdot}000111$, $p\Delta T_{00} = \pm 0^s{\cdot}011$.

At time T, $p\Delta T = \pm \sqrt{0^s{\cdot}000111 + 0^s{\cdot}000171 \,.\, (T - 9^h{\cdot}84)^2}$.

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On the Photographic Magnitude of Nova Aurigæ, as Determined at the Royal Observatory, Greenwich. II. By W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

In the *Monthly Notices* for last March (vol. lii. p. 357) results for the photographic magnitude of *Nova Aurigæ* were given as determined up to March 9. Since then photographs have been taken up to April 1, when the photographic magnitude had fallen below 14, and again at the end of August and beginning of September, when the star had brightened. Further measures were also made of the earlier photographs, modifying slightly the results given in the previous paper. The measures were made and reduced in the manner explained in that paper, the magnitude of the *Nova* being inferred by comparison with four Argelander stars of 8–9 magnitude by means of the formula

$$m = 2{\cdot}5\,(\log t - 0{\cdot}97\sqrt{d}) + \text{const.}$$

given in the *Monthly Notices*, vol. lii. p. 146, the measures of diameter of the four comparison stars being used to determine

the value of the constant for each plate. Their magnitudes taken from Argelander are: B.D. +30°·944, 8·2; +30°·949, 8·2; +30°·938, 8·7; +30°·913, 8·7; and it is assumed that the mean magnitude of the four stars is 8·45.

The results are given in the accompanying Table I. The initials A.E., E.R., A.R., W.C., C. are those of Miss Everett, Miss Rix, Miss Russell, Mr. Christie, and Mr. Criswick respectively.

TABLE I.

Photographic Magnitude of Nova Aurigæ from Comparisons with Four Stars, 8–9 Mag.

1892.		A.E. Mag.	E.R. Mag.	A.R. Mag.	W.C. Mag.	C. Mag.	Mean Adopted Magnitude.
Feb.	1	$4{\cdot}29_1$	$4{\cdot}60_1$	$4{\cdot}51_1$	$4{\cdot}53_1$	$4{\cdot}56_1$	4·50
	2	$3{\cdot}71_3$	$3{\cdot}14_2$	$3{\cdot}75_3$	...	$3{\cdot}81_3$	3·69
	3	$3{\cdot}69_3$	$3{\cdot}45_3$	...	$3{\cdot}60_2$	...	3·57
	12	$4{\cdot}23_4$	$3{\cdot}66_4$	...	$3{\cdot}46_2$	...	3·81
	13	$4{\cdot}50_3$	$4{\cdot}28_3$	$4{\cdot}37_3$	...	...	4·39
	18	$3{\cdot}99_6$	$3{\cdot}72_6$	$3{\cdot}95_3$	...	$4{\cdot}15_3$	3·94
	22	$4{\cdot}83_3$	...	$4{\cdot}34_3$	...	...	4·61
Mar.	7	$5{\cdot}05_4$	...	...	...	...	5·05
	9	$6{\cdot}30_7$	...	...	...	...	6·30
	10	$6{\cdot}77_2$	...	$6{\cdot}50_2$	...	...	6·64
	14	$8{\cdot}10_2$	...	$7{\cdot}87_1$	...	...	8·02
	15	$8{\cdot}03_3$	...	$7{\cdot}86_2$	...	...	7·95
	15	$8{\cdot}64_3$	...	$8{\cdot}62_3$	...	...	8·63
	18	$9{\cdot}47_2$	...	$9{\cdot}61_3$	...	...	9·55
	18	$9{\cdot}03_2$	...	$9{\cdot}47_3$	...	...	9·25
	19	$10{\cdot}03_3$	...	$10{\cdot}08_3$	...	...	10·06
	24	$11{\cdot}78_2$	...	$11{\cdot}27_2$	...	...	11·53
	28	$12{\cdot}48_3$	...	$13{\cdot}26_3$	...	$11{\cdot}68_2$	12·57
	30	$13{\cdot}08_2$	...	$13{\cdot}63_2$	...	...	13·36
Apr.	1	$14{\cdot}53_1$	...	$14{\cdot}21_1$	...	...	14·37
Aug.	30	$11{\cdot}63_2$	...	$12{\cdot}47_2$	$11{\cdot}77_2$	$11{\cdot}24_2$	11·78
Sept.	3	$11{\cdot}72_2$	...	$13{\cdot}11_2$	...	...	12·42
	5	...	...	$12{\cdot}55_3$	...	...	12·55
	6	$11{\cdot}73_4$	...	$12{\cdot}07_4$	...	...	11·90

The number of images of the *Nova* measured on each day is indicated by the suffix, the exposures ranging generally from 15^s to 12^m, as shown in the previous paper. This scale of exposures was, however, to some extent modified when the *Nova* got

too faint to be shown with the short exposures, and the following is a list of the exposures from March 19: March 19 and 24, 12^m, 4^m, 1^m; March 28, 12^m, 6^m; March 30, 20^m, 10^m, 30^s, 15^s; April 1, 30^m, 15^m, 30^s, 15^s; August 30 and September 3, 12^m, 4^m, 1^m; September 5, 12^m, 5^m, 4^m, 1^m; September 6, $8\frac{1}{2}^m$, 4^m, $2\frac{1}{4}^m$, 1^m, 30^s. On March 30 the *Nova* was shown with an exposure of 10^m, on April 1 with an exposure of 30^m, and on September 6 with an exposure of 1^m.

On March 15 and 18 two sets of exposures were given, the first with the *Nova*, and the second with the 5·7 mag. star B.D. +30°·898, at the centre of the plate, the *Nova* in the second set being about 60′ from that centre. These plates were taken to test whether distance from the centre would appreciably affect the determination of photographic magnitude.

The following are the values of photographic magnitude of BD + 30°·898 deduced in the two cases:—

Star 60′ from centre of plate.

Exposure.	1892 March 15, Plate 293. A.E.	A.R.	March 18, Plate 296. A.E.	A.R.
12^m	4·79	4·59	4·41	4·50
30^s	4·51	4·36	4·31	4·29
15^s	4·06	3·96	4·24	4·24
Mean of 3 ...	4·45	4·30	4·32	4·34
Mean of all exposures			4·36	

Star at centre of plate.

12^m	4·39	4·31	4·84	4·34
30^s	4·24	4·11	3·91	4·22
15^s	4·11	3·96	3·99	3·97
Mean of 3 ...	4·25	4·13	4·25	4·18
Mean of all exposures			4·20	

In connection with these measures it may be of interest to give the value of the constant deduced from each plate (the meaning of which has been explained in the previous paper, p. 364), Table II., and the results obtained for the photographic magnitudes of the four comparison stars referred to the mean of the four, which is assumed from Argelander to be 8·45, Tables III. and IV.

In explanation of the small values of the constant in some cases, it is to be remarked that several of the nights on which the photographs were taken were cloudy or hazy. This was the case on March 7, 9, 10, 14, and 15.

TABLE II.

Values of the Constant for each Plate from Measures of the Four Comparison Stars, 8–9 Mag.

1892.		A.E. Const.	E.R. Const.	A.R. Const.	W.O Const.	C. Const.	Mean Value of Constant.
Feb.	1	$10{\cdot}22_1$	$10{\cdot}30_1$	$9{\cdot}86_1$	$10{\cdot}23_1$	$10{\cdot}71_1$	10·26
	2	$9{\cdot}05_3$	...	$8{\cdot}64_2$	...	$9{\cdot}24_2$	8·98
		$8{\cdot}43_2$	...	$8{\cdot}32_2$	...	$8{\cdot}71_2$	8·49
		$9{\cdot}51_3$	$9{\cdot}23_3$	$9{\cdot}27_3$	...	$9{\cdot}87_3$	9·47
	3	$9{\cdot}15_3$	$8{\cdot}74_3$	...	...	...	8·95
		$8{\cdot}55_2$	$8{\cdot}12_2$	...	...	...	8·34
		$8{\cdot}77_3$	$8{\cdot}42_3$	...	$8{\cdot}61_3$	...	8·60
	12	$9{\cdot}28_3$	$8{\cdot}65_3$	...	$8{\cdot}65_3$	...	8·86
		$8{\cdot}82_1$	$8{\cdot}86_1$	...	...	...	8·84
	13	$8{\cdot}60_2$	$8{\cdot}46_2$	...	...	...	8·53
		$8{\cdot}53_3$	$7{\cdot}96_3$	$8{\cdot}04_3$	...	...	8·18
		$8{\cdot}36_3$	$7{\cdot}71_3$	...	...	...	8·04
	18	$9{\cdot}07_3$	$9{\cdot}01_3$	$9{\cdot}23_3$	...	...	9·10
		...	...	$9{\cdot}56_2$	...	$9{\cdot}89_2$	9·73
		$9{\cdot}24_3$	$9{\cdot}22_3$	$9{\cdot}38_3$	...	$9{\cdot}55_3$	9·35
	22	$9{\cdot}70_3$	...	$9{\cdot}41_3$	...	...	9·56
		...	...	$9{\cdot}74_3$	...	...	9·74
		$9{\cdot}96_3$	...	...	...	...	9·96
Mar.	7	$8{\cdot}82_3$	...	...	...	...	8·82
		$8{\cdot}34_3$	...	...	...	...	8·34
	9	$8{\cdot}96_3$	...	...	...	...	8·96
		$8{\cdot}35_4$	...	...	...	...	8·35
	10	$7{\cdot}47_2$	...	$7{\cdot}29_2$	...	...	7·38
	14	$6{\cdot}19_1$	...	$6{\cdot}22_1$	...	...	6·21
	15	$8{\cdot}84_3$	...	$8{\cdot}69_3$	...	...	8·77
		$8{\cdot}45_2$	...	$8{\cdot}21_2$	...	...	8·33
	18	$9{\cdot}19_3$	...	$9{\cdot}12_3$	...	...	9·16
		$9{\cdot}04_3$	...	$8{\cdot}81_3$	...	...	8·93
	19	$9{\cdot}23_3$	...	$9{\cdot}18_3$	...	...	9·21
	24	$9{\cdot}10_3$	...	$8{\cdot}67_3$	...	...	8·89
	28	$8{\cdot}54_2$	...	$8{\cdot}55_2$	...	$8{\cdot}69_2$	8·59
		$8{\cdot}37_2$	...	$8{\cdot}36_2$	...	...	8·37
	30	$9{\cdot}46_4$	...	$9{\cdot}58_4$	...	...	9·52
Apr.	1	$8{\cdot}83_4$	...	$8{\cdot}83_4$	...	...	8·83
Aug.	30	$9{\cdot}59_3$	...	$9{\cdot}94_3$	$9{\cdot}63_3$	$9{\cdot}78_3$	9·74
Sept.	3	$9{\cdot}18_3$	...	$9{\cdot}58_3$	...	...	9·38
	5	...	...	$10{\cdot}03_1$	...	...	10·03
	6	$9{\cdot}43_4$	...	$9{\cdot}53_4$	...	...	9·48
		$8{\cdot}90_1$	...	$9{\cdot}25_1$	...	...	9·08

TABLE III.

Photographic Magnitudes of the Four Comparison Stars, referred to the Mean of the Four.

Date. 1892.		Measurer.	B.D.+30° 944.	Mean.	+30° 949.	Mean.	+30° 938.	Mean.	+30° 913.	Mean.
Feb.	1	A.E.	7·99$_1$		8·31$_1$		8·81$_1$		8·47$_1$	
		E.R.	8·05$_1$	7·97	8·27$_1$	8·25	8·80$_1$	8·83	8·67$_1$	8·67
		A.R.	7·88$_1$		8·18$_1$		8·88$_1$		8·86$_1$	
	2	A.E.	7·89$_2$		8·40$_2$		8·67$_2$		8·84$_2$	
		E.R.	7·91$_2$	7·92	8·49$_2$	8·35	8·63$_2$	8·68	8·78$_2$	8·85
		A.R.	7·96$_2$		8·24$_2$		8·71$_2$		8·89$_2$	
	3	A.E.	8·06$_2$	7·99	8·54$_2$	8·51	8·61$_2$	8·61	8·74$_7$	8·80
		E.R.	7·91$_2$		8·48$_2$		8·60$_2$		8·86$_7$	
	12	A.E.	7·97$_4$	8·01	8·24$_4$	8·19	8·64$_4$	8·74	9·03$_2$	8·95
		E.R.	8·04$_4$		8·13$_4$		8·83$_4$		8·86$_2$	
	13	A.E.	8·03$_2$		8·30$_2$		8·65$_2$		8·84$_2$	
		E.R.	8·00$_2$	8·02	8·32$_2$	8·24	8·59$_2$	8·65	8·88$_2$	88·5
		A.R.	8·05$_2$		8·17$_2$		8·79$_2$		8·80$_2$	
	18	A.E.	7·84$_6$		8·10$_6$		8·70$_6$		9·16$_6$	
		E.R.	7·93$_6$	7·84	7·87$_6$	8·01	8·68$_6$	8·71	9·34$_6$	9·25
		A.R.	7·78$_2$		8·03$_2$		8·75$_2$		9·24$_2$	
	22	A.E.	8·00$_2$	8·42	8·24$_2$	8·22	8·78$_2$	8·79	8·78$_2$	8·82
		A.R.	8·93$_2$		8·19$_2$		8·80$_2$		8·87$_2$	
Mar.	7	A.E.	7·84$_2$	7·84	8·37$_2$	8·37	8·72$_2$	8·72	8·89$_2$	8·89
	9	A.E.	8·04$_7$	8·04	8·27$_7$	8·27	8·63$_7$	8·63	8·86$_7$	8·86
	10	A.E.	7·82$_2$	7·87	8·39$_2$	8·46	8·56$_2$	8·55	9·05$_2$	8·95
		A.R.	7·92$_2$		8·52$_2$		8·53$_2$		8·85$_2$	
	14	A.E.	7·77$_2$	7·77	8·12$_1$	8·02	8·59$_1$	8·68	9·32$_1$	9·34
		A.R.	7·77$_1$		7·92$_1$		8·77$_1$		9·35$_1$	
	15	A.E.	8·13$_2$	8·19	8·59$_2$	8·38	8·81$_2$	8·80	8·43$_2$	8·53
		A.R.	8·24$_2$		8·16$_2$		8·78$_2$		8·63$_2$	
	15	A.E.	...		...		...		9·20$_1$	8·87
		A.R.	...		...		...		8·71$_2$	
	18	A.E.	7·49$_2$	7·50	8·46$_2$	8·54	8·65$_2$	8·67	9·21$_2$	9·11
		A.R.	7·51$_2$		8·61$_2$		8·69$_2$		9·01$_2$	
	18	A.E.	...		...		...		8·70$_2$	8·70
		A.R.	...		...		...		8·70$_2$	

Date. 1892.	Measurer.	B.D.+30° 944.	Mean.	+30° 949.	Mean	938.	Mean.	913.	Mean.
Mar. 19	A.E.	$7{\cdot}78_2$	7·85	$8{\cdot}29_2$	8·27	$8{\cdot}74_2$	8·72	$8{\cdot}99_2$	8·98
	A.R.	$7{\cdot}91_2$		$8{\cdot}24_2$		$8{\cdot}69_2$		$8{\cdot}97_2$	
24	A.E.	...		...		...		$8{\cdot}70_2$	8·70
	A.R.	...		...		...		$8{\cdot}70_2$	
28	A.E.	$8{\cdot}05_4$	8·00	$8{\cdot}52_4$	8·33	$8{\cdot}85_4$	8·83	$8{\cdot}65_4$	8·78
	A.R.	$7{\cdot}95_4$		$8{\cdot}13_4$		$8{\cdot}80_4$		$8{\cdot}91_4$	
30	A.E.	$8{\cdot}03_4$	8·06	$8{\cdot}04_4$	8·17	$8{\cdot}77_4$	8·72	$8{\cdot}98_4$	8·86
	A.R.	$8{\cdot}09_4$		$8{\cdot}30_4$		$8{\cdot}67_4$		$8{\cdot}73_4$	
Apr. 1	A.E.	$7{\cdot}95_4$	7·95	$8{\cdot}36_4$	8·25	$8{\cdot}80_4$	8·86	$8{\cdot}67_4$	8·73
	A.R.	$7{\cdot}95_4$		$8{\cdot}13_4$		$8{\cdot}91_4$		$8{\cdot}79_4$	
Aug. 30	A.E.	$8{\cdot}05_2$	8·05$_2$	$8{\cdot}36_2$	8·35$_2$	$8{\cdot}76_2$	8·76	$8{\cdot}65_2$	8·68
	A.R.	$8{\cdot}04_2$		$8{\cdot}33_2$		$8{\cdot}75_2$		$8{\cdot}70_2$	
Sept. 3	A.E.	$8{\cdot}06_2$	8·03	$8{\cdot}24_2$	8·24	$8{\cdot}68_2$	8·69	$8{\cdot}84_2$	8·86
	A.R.	$7{\cdot}99_2$		$8{\cdot}24_2$		$8{\cdot}69_2$		$8{\cdot}87_2$	
5	...	...		...		...		...	
	A.R.	$7{\cdot}75_4$	7·75	$8{\cdot}69_4$	8·69	$8{\cdot}62_4$	8·62	$8{\cdot}83_4$	8·83
6	A.E.	$7{\cdot}89_5$	7·85	$8{\cdot}03_5$	8·11	$8{\cdot}89_5$	8·81	$9{\cdot}01_5$	8·95
	A.R.	$7{\cdot}81_5$		$8{\cdot}18_5$		$8{\cdot}72_5$		$8{\cdot}89_5$	

TABLE IV.

Mean Photographic Magnitudes of the Four Comparison Stars.

Measurer.	1st Star. B.D+30°. No. 944.	2nd Star. +30°. No. 949.	3rd Star. +30°. No. 938.	4th Star. +30°. No. 913.
A.E.	$7{\cdot}95_{80}$	$8{\cdot}31_{88}$	$8\,71_{89}$	$8{\cdot}85_{94}$
E.R.	$7{\cdot}96_{30}$	$8{\cdot}26_{30}$	$8{\cdot}65_{30}$	$8{\cdot}95_{28}$
A.R.	$7{\cdot}91_{61}$	$8{\cdot}24_{62}$	$8{\cdot}74_{62}$	$8{\cdot}88_{72}$
W.C.	$7{\cdot}97_{10}$	$8{\cdot}28_{10}$	$8\,74_{10}$	$8{\cdot}80_{8}$
C.	$7{\cdot}92_{19}$	$8{\cdot}42_{19}$	$8{\cdot}67_{19}$	$8{\cdot}80_{19}$
Mean of 1st 3 Observers' Measures	$7{\cdot}94_{183}$	$8{\cdot}28_{181}$	$8{\cdot}71_{181}$	$8{\cdot}88_{194}$
Mean of all the Measures.	$7{\cdot}94_{212}$	$8{\cdot}29_{210}$	$8{\cdot}71_{210}$	$8{\cdot}87_{221}$

The results for photographic magnitude of the four comparison stars may serve to show the degree of consistency which may be expected in determinations of magnitude deduced from measures of diameter of star-disks.

Royal Observatory, Greenwich:
1892 November 11.

Estimations of Magnitude of Nova Aurigæ, made with the Barclay Equatoreal, at the Radcliffe Observatory, Oxford.

(*Communicated by E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.*)

1892.	h	Observer.	Power of Eye-piece used.	Observed Magnitude of *Nova*.	Comparison Stars.	Remarks.
Sept. 8	13	R.	85	9·5	*a*, *k*, *h*	Moonlight.
13	12	R.	,,	9·5	*a*, *k*, *h*	
15	12	R.	,,	9·4	*a*, *k*, *h*	*Nova* possibly a trifle brighter than on September 13.
17	11	R.	,,	9·6	*a*, *k*, *h*	
24	12	W.	,,	9·9	*a*, *k*, *h*, *g*, *i*	
28	11	R.	,,	9·4	*a*, *k*, *h*	
30	12	R.	,,	9·6	*a*, *k*, *h*	
Oct. 5	12	R.	,,	9·5	*a*, *k*, *h*	Moonlight.
7	11	R.	,,	9·5	*a*, *k*, *h*	
10	10	P.	,,	9·5	*a*, *k*, *h*	Moon near. *Nova* at times nearly as faint as *a*.
17	12	W.	,,	10·0	*a*, *k*, *h*, *g*, *i*	
D ,,		,,	100	9·9	*e*, *g*, *i*	Images not sharp with any power, but ξ is visible.
,,		,,	180	9·9	*a*, *k*, *h*, *g*, *i*	

Estimations of Magnitude of Nova Aurigæ.—(continued).

1892.	h	Observer.	Power of Eye-piece used.	Observed Magnitude of *Nova*.	Comparison Stars.	Remarks.
Oct. 18	11	R.	85	9·6	*a*, *k*, *h*	
19	11	W.	"	9·7	*a*, *k*, *h*, *g*, *i*	The contrast between the *Nova* and *a* is, I believe, stronger to-night than on October 17.
25	11	R.	"	9·8	*a*, *k*, *h*	*Nova's* image is dull.
29	11	R.	"	9·7	*a*, *k*, *h*	The image of the *Nova* is rather dull.
"		"	180	9·6	*a*, *k*, *h*	There is a slightly greater difference in magnitude between the *Nova* and *a* with power 180 than with 85.

Observers: W., Mr. W. Wickham; R., Mr. W. H. Robinson.

The comparison star *h* was generally observed to be 0·1 of a magnitude *brighter* than *k*. The exceptions were:—September 24, fainter than *k*; September 30, equal to *k*; October 19, 0·2 fainter than *k*; October 25 and 29, equal to *k*.

The adopted magnitudes of the comparison stars are given in the *Monthly Notices* of the R.A.S., vol. lii., page 431, and depend fundamentally upon the magnitude assigned by Argelander to the star *k* (D.M. + 30°, No. 924), viz. 9·5.

Radcliffe Observatory, Oxford:
1892 *November* 10.

Nova Aurigæ. By E. E. Barnard, M.A.

The first time I ever saw the object with the 36-inch was 1892 August 19. As soon as I saw it I was struck with the fact that it was really a very small nebula, "some 5″ in diameter," with a 10th-magnitude stellar nucleus. The nebulosity was very dense and whitish, and with a low power might escape notice. A setting of the wires gave the diameter of the nebulosity as 3″. The star nucleus was from $0^{m}1$ to $0^{m}2$ less than the star F of Mr. Burnham's diagram (*Monthly Notices*, vol. lii., No. 6). But with low power, as a whole, the nebula and nucleus were brighter than that star. At every observation since the nebulosity has been a striking object—the colour of nebula and nucleus being a bluish white—quite in contrast to the star F, which has appeared slightly yellow.

The light seems to have been declining very slowly. At the last observation, October 23, the nucleus was fully one magnitude less than F, and the nebulosity seemed less bright and was smaller in extent. The bluish-white colour was still strikingly marked.

To detect any motion perpendicular to the line of sight I have repeated Mr. Burnham's measures of last spring with two of his stars, so selected as to show motion if it existed.

Here are the observations, all made with the micrometer of the 36-inch:—

	A *and* E.			A *and* F.	
1892·64	323°·3	74″·24	1892·64	32°·6	85″·03
·66	323·5	74·41	·66	32·8	84·76
·67	323·5	74·64	·67	32·7	84·87
·70	323·5	74·75	·70	32·6	85·04
1892·67	323·5	74·51 B4*n*		32·7	84·92 B4*n*

Mr. Burnham's measures of the same stars are:—

	A *and* E.			A *and* F.	
1892·14	323°·6	74″·24 β3*n*	1892·12	32°·4	85″·05 β4*n*

A comparison of these measures do not show with certainty any motion in A. But the distance A E seems to be increasing. If this is real, and it seems to be so, it is strange that before my observations, it is not apparent, as compared with those of Mr. Burnham. Measures will be made to decide whether this motion is real, and if so, as to whether it is in A or E.

Mount Hamilton:
1892 *October* 24.

Discovery of a Comet by Photography. By E. E. Barnard, M.A.

On October 12 I made an exposure on the Milky Way near and west of α *Aquilæ* of 4 hours 20 minutes' duration with the Willard lens.

Upon developing the plate I found a distinct hazy trail near the middle of it, and about a quarter of a degree long. By this time the position of the object was too near the horizon to make a search for it. The next night (13th), as soon as it was dark enough, a search was made with the 12-inch, and the object was found nearly a degree south-east of the position on the photograph. A few minutes' observation showed it to be a comet in motion to the south-east. The comet was very faint in the 12-inch, about the thirteenth magnitude, round, and but little brighter in the middle. It has been carefully observed at every opportunity since.

This object is an exact representative of Class I. of short-period comets, very much resembling in appearance D'Arrest's comet.

The micrometer position on October 13 was—

1892 October 13^d 7^h 12^m 29^s Mount Hamilton M.T.

App. $\alpha = 19^h\ 33^m\ 57^s{\cdot}56$

App. $\delta = +12^\circ\ 30'\ 5''{\cdot}0$

From the faintness of the comet in the telescope, and the strength of its trail in the plate, it is evident that its light is mainly actinic. The plate used was a Cramer "Lightning," a very rapid and fine plate.

Mount Hamilton:
1892 *October* 24.

Note on the Period and Distance of the Fifth Satellite of Jupiter.
By E. E. Barnard, M.A.

This satellite was discovered here by the writer at midnight, 1892, September 9, with the 36-inch equatoreal.

From the eastern elongations of September 10 and October 21 the following periodic time results: $11^h\ 57^m\ 20^s{\cdot}5$. Hourly motion $30^\circ{\cdot}111$.

The period of $17^h\ 36^m$ distributed in Europe was an error in telegraphic transmission. The period of $11^h\ 50^m$ sent later was erroneously derived from the observed distances of the satellite.

From seven eastern observed elongations the distance of the satellite (at east elongation) is $48''{\cdot}094$ (at 5.20). This corresponds to a distance from *Jupiter's* centre of 112,510 miles. The few observed western elongations give a distance about

1″ less than this, and there is evidently sensible ellipticity to the orbit.

At present the satellite is assumed to be of the 13th magnitude. Under the most favourable conditions it has not been possible to see the shadow of this object when in transit. From these and other considerations the satellite is probably not over 100 miles in diameter. Taking everything into consideration the brightness at east and west elongations is the same.

Mount Hamilton:
1892 *October* 24.

P.S.—Following are two of the last observed *east elongations* of the satellite:—

1892.	d	h	m	
Oct.	21	17	2·8	G.M.T. computed from measures before and after elongation.
	23	16	49·0	" " " "

The measured distance at east elongation of the 23rd was—
62″·90

October 26.

On the Sidereal Period of the New Satellite of Jupiter.

By the Rev. A. Freeman, M.A.

Upon examination of Professor E. E. Barnard's most important paper upon the "Discovery and Observation of a Fifth Satellite of Jupiter," published in No. 275 of the *Astronomical Journal*, for October 4, 1892, it seems probable that an error has been made in deducing the period from the concluded apparent distances of the satellite at its elongations, September 10, 12, and 14. Professor Barnard employs the formula—

$$P = p\sqrt{\frac{m}{M}\cdot\frac{R^3}{r^3}},$$

in which he states that m is the mass of the Earth, and M that of *Jupiter*, p and r the periodic time and geocentric radius of our Moon, P and R the periodic time and jovicentric radius of the new satellite. But, if he had desired to compare the period with that of our Moon, he ought to have employed the formula,

$$P = p\sqrt{\frac{m+m^1}{M+m_0}\cdot\frac{R^3}{r^3}},$$

in which $m^1 = \frac{1}{81}m$ (nearly) is the mass of the Moon, and m_0 is the mass of the new satellite, so small as to be neglected in comparison with the mass of *Jupiter*. Unless, therefore, the "*mass of the Earth*" meant by Mr. Barnard includes that of the Moon also, his resulting period is manifestly and decidedly too small.

I prefer to compare the motion of the new satellite with that of the first hitherto known satellite of *Jupiter*.

The exact formula to be employed is

$$\frac{P}{P_1} = \sqrt{\frac{M+m_1}{M+m_0} \cdot \frac{R^3}{R_1^3}},$$

where M is the mass of *Jupiter*, m_0 and m_1 the masses of the new and first satellites, R and R_1 their jovicentric radii. We can, however, safely neglect the masses of both satellites, and use the simple expression—

$$P = P_1 \left(\frac{R}{R_1}\right)^{\frac{3}{2}}.$$

From Barnard's apparent elongations, September 10, 12, 14, viz.: 61″·04, 61″·55, 61″·50, which correspond to G.M.T. $20^h\ 53^m$, $20^h\ 38^m$, $20^h\ 24^m$ (with sufficient accuracy), on the respective dates, I find by multiplying the apparent elongations in seconds of arc by the concluded geocentric radii of *Jupiter*, taken from the *Nautical Almanac*, and dividing by 5·202800, the heliocentric mean radius of *Jupiter*, that 47″·9613, 48″·1666, 48″·0217 are the corresponding elongations of the new satellite as viewed from the Sun at the mean distance of *Jupiter* on September 10, 12, 14. The mean of these three is 48″·04993.

Now Bessel and Schur have given 111″·7360 and 111″·6523 for the mean elongation of Sat. I. of ♃, at ♃'s mean distance from the Sun. The mean of these two measures is 111″·6942. Moreover, the mean sidereal period of Sat. I. is 1·7691378 mean solar days. Hence we have

$$P = \left(\frac{48\cdot04993}{111\cdot6942}\right)^{\frac{3}{2}} \cdot 1^d\cdot7691378,$$

whence

$$P = 0^d\cdot4991775$$
$$= 11^h\ 58^m\ 48^s\cdot9$$

as the sidereal period of the new satellite. It is remarkable that this differs little from $11^h\ 59^m$, the period which is accepted by Mr. S. W. Burnham in a communication to the *Chicago Academy of Sciences*, at their meeting, 1892 October 4. (See *Observatory*, 1892 November.)

Further measures of elongation distances will no doubt soon be published by Mr. Barnard, and may be used to correct the period found above.

Murston Rectory:
1892 November 9.

Addendum.

Taking the necessary data from Professor W. Harkness's *The Solar Parallax and the Related Constants*, and employing the second formula in the foregoing paper, I find—

$$\frac{P}{27^d{\cdot}32166116} = \left(\frac{1047{\cdot}55}{327214}\right)^{\frac{1}{2}} \left(\frac{5{\cdot}2028 \times 92796950 \times \sin 48''{\cdot}05}{238854{\cdot}75}\right)^{\frac{3}{2}}$$

$$= 0{\cdot}5002246 \text{ days}.$$

$$= 12^h\ 0^m\ 13^s{\cdot}4.$$

An error of even $\frac{1}{20}$th of a second of arc in the assumed distance 48″·05 makes an appreciable difference in the resulting period. The best way of obtaining the true result is to infer it from the number of revolutions and parts of a revolution made by the satellite between the times of two distant elongations, as has now been done by Mr. A. Marth and Professor Barnard, whose periods thereby derived agree within half a second of time. The period found by Mr. Marth is $11^h\ 57^m{\cdot}33$.

1892 *November* 15.

Enlarged Star and Moon Photographs. By H. C. Russell, B.A., F.R.S.

In making another enlargement of the photograph of the stars and nebulæ about *η Argûs* to replace the one destroyed in transit, it seems desirable to make it upon the same scale as Herschel's beautiful picture of that object published in the Cape observations, thus ensuring convenient comparison. This involved enlarging the original photograph, the scale of which is 2·3 ins. to 1°, up to 15 ins. to 1°, and the result is a strong testimony to the quality of the original negative. I have sent both positive and negative on paper. The paper negative of course involved making a positive by contact printing, in which much detail is lost. A comparison of these photographic enlargements with Herschel's drawing is very suggestive, both in regard to the difference in delineation and extent of the nebula by the eye and the sensitive plate, particularly in the great mass of detail which the camera brings out in the denser parts, and also the vastly greater number of stars, probably ten times as many in the photograph as in the drawing. (The original negative was exposed $5\frac{3}{4}$ hours.) I send also an enlargement of the same object (*η Argûs*) from a negative taken with a 6-inch diameter Dallmeyer portrait lens, and 8 hours exposure, on a scale of 0·556 in. = 1°, enlarged to 3 ins. = 1°. This enormously extends the area of the nebula, and shows that the dark markings which begin at the centre of the mass extend in curiously meandering lines to great distances, in several places enclosing nearly circular spaces. Looking at this photograph the nebula seems to spread out almost without limit, as indicated by the dark lanes which bring it into prominence; but the more definite parts, about which the connection with the central mass cannot be doubted, cover a space measured by 2° in R.A. and 3° in Decl., while the photograph taken with the star camera and $5\frac{3}{4}$ hours'

exposure is less than 1° in R.A. and less than 1¼° in Decl., an area as nearly as possible of 1°; while in the one taken with the portrait camera it covers an area of at least 6°.

The photograph must speak for itself, but there is one feature of special interest. Herschel's lemniscate—at least the greater part of it—seems quite black to the eye aided by large telescopes, and the same in the photograph with the star camera, but it will be seen that in the one with the portrait camera it is not without nebulous light, and the prolonged exposure has brought it out sufficiently to fill up the dark space completely, while the dark oval which Herschel describes so carefully at R.A. – 100 and Decl. + 900 of his drawing is in the photograph absolutely dark, and thrown into great prominence by the brilliance of the nebulous light around it. I have also sent two enlargements of portions of the Moon, one showing *Copernicus* nearly 1 inch in diameter (scale for whole Moon 34 ins.), with corresponding detail inside and outside the crater; this is from a negative taken direct, 5½ ins. in diameter: also a portion of the Apennine mountains, on a scale of 65 ins. = diameter of the Moon. The negative for this was taken direct on a scale of 20 ins. to diameter of Moon. Both these Moon pictures contain more detail than any I have seen; the latter especially brings the precipices, clefts, and valleys of the Apennines into striking prominence, on a scale which makes *Archimedes* 1¾ in. in diameter.

Sydney Observatory:
1892 *September* 17.

The Motion of ζ Cancri. By S. W. Burnham, M.A.

In a paper entitled "Invisible Double Stars" (*Monthly Notices*, April, 1891) I gave the result of an investigation of the observed positions of the star C of this system. From this it appeared that, while the observed places of this star were apparently arranged in somewhat regular groups, all of the stars of the same class which were examined showed the same tendency, and with about the same regularity. The question to be solved was whether this apparent want of uniformity in the motion of the star was to be ascribed to the disturbance produced by some unknown and invisible body, or to the ordinary errors of observation. While there is nothing, perhaps, improbable in the theory that non-luminous stars may exist throughout space, and may be components of binary systems, still it is at present a speculation at best, and it is obvious that it should be adopted as an explanation of actual observations only when the ordinary ways of accounting for apparent discordances have been positively shown to be insufficient. There would be less room for debate if *ζ Cancri* were the only example of this kind, but I have shown that in other stars, selected at random from those having an angular movement around their primaries of about the same

amount, all show without exception the same apparently variable motion, more or less prominently. This suggests the possibility, at least, that the explanation may be found in the errors of observation. Otherwise we are forced to admit the existence of many more "dark suns" than one could reasonably expect to find in a single class of binary stars.

I also suggested that the best way to determine this interesting question in the case of *ζ Cancri* would be to measure C from some outside star, entirely disconnected from the triple system. By keeping up regularly for a few years a careful system of measures, it could doubtless be shown whether or not the motion of C was uniform. It seemed to me that measures of the difference of the declinations of C and some convenient star in the vicinity would be most likely to avoid the errors which to some extent would certainly be found in measures connecting C with the close pair, A B; and I called attention to a $7\frac{1}{2}$ *m* star (Lalande 12262) about 2^m following *ζ Cancri*, and 1″·5 north, as being suitable for this comparison and also to a 9 *m* D M. star nearly following, which could be used for angular measures only. Obviously measures of the difference of declination are superior to any other for determining change. With the telescope stationary the bisections can be made with an accuracy not attainable in direct measures of considerable distances. In this case the sole question to be determined, in the first instance, is whether any change in the relative positions of these two stars in declination is uniform. Change due to the proper motion of either star, or to the orbital movement of C about the close pair, can, of course, be wholly neglected, since that will be a constant quantity.

In the interest of the solution of this question I have put these suggestions in practice, and have made each year a careful set of measures of C, with reference to the star which follows, for the difference in declination; of C from A and B as separate stars; and of the angular direction of the small star, D M. (18°) 1870. The aperture in inches of the telescope employed is given in the last column.

C. *and* Ll. 12262.

1891·225	Diff. Decl. 103″·89	...	36
·227	101·05	...	36
·236	104·08	...	12
·241	103·99	...	36
		h m	
1892·057	103·80	Sid^{l}. Time 7 35	36
·085	103·72	8 00	36
·118	103·97	8 25	36
·153	103·99	8 00	36
·156	103·87	8 15	36

C. *and* D.M. (18°) 1870.

1891·181	Pos. Angle 108°17	...	12
·208	108·33	...	12
·214	108·14	...	12
·222	108·32	...	12
·225	108·28	...	36
·227	108·15	...	36
·239	108·31	...	36
·241	108·17	...	36
		h m	
1892·057	107·90	Sid^{l}. Time 7 30	36
·156	108·25	8 00	36
·173	108·50	6 25	36
·186	108·35	8 10	36

A. *and* C.

1891·181	117°6	5″45	12
·214	117·2	5·49	12
·222	115·9	5·42	12
·225	117·3	5·57	36
·227	116·2	5·58	36
·239	115·5	5·52	36
1892·057	115·3	5·51	36
·153	116·5	5·41	36
·156	117·7	5·42	36
·186	117·3	5·58	36

B. *and* C.

1891·181	128°1	5″52	12
·214	127·6	5·66	12
·222	128·5	5·56	12
·225	127·4	5·58	36
·227	127·7	5·61	36
·239	127·3	5·69	36
1892·057	127·4	5·66	36
·153	128·3	5·48	36
·156	127·6	5·52	36
·186	127·5	5·46	36

A. *and* B.

1892·153	32°·7	1″·04	3δ
·186	33·2	1·02	3δ
1892·17	33·0	1·03	

The mean results of the two sets of measures are as follows:—

C. *and* Ll. 12262.

1891·23	Diff. Decl. 104″·00	4*n*
1892·11	103·87	5*n*

C. *and* D.M. (18°) 1870.

1891·22	Pos. Angle 108°·23	8*n*
1892·14	108·00	4*n*

A. *and* C.

1891·22	116°·6	5″·50	6*n*
1892·14	116·7	5·48	4*n*

B. *and* C.

1891·22	127°·8	5″·60	6*n*
1892·14	127·7	5·53	4*n*

All of the measures were made near the meridian, and under favourable atmospheric conditions. I have not noted the sidereal time in the first observations of the distant stars, but the slight change due to refraction is of no practical consequence, and in any event it is essentially the same for all the observations. In the measures of C from the components of the close pair, high powers were always used, and A and B were widely separated; at the same time it is not easy, and perhaps impossible, to prevent the presence of a third star, within 1″ of that which is being measured, from having some effect in the placing of the wires both in angle and distance. I rely principally upon the measures of declination. It will be well, however, to continue all the measures of the stars used here; but I think it is important that the aperture and power used should be sufficient to observe the components of the close pair separately. I do not think measures of C from A B as one star would have much value in determining whether or not the movement of the first-named star is variable.

Doubtless other observers who have taken an interest in this question of an invisible disturbing body have already commenced observations similar to those given here. I trust that this is so, and that they will be systematically continued until sufficient data are obtained to settle the point definitely by the best evidence of all.

Chicago: 1892 *October* 17.

On the Orbit of Σ 2525. By J. E. Gore.

A recent measure of this binary star made by Mr. Burnham with the 36-inch refractor of the Lick Observatory shows that the companion has described about 288° of its apparent ellipse since its discovery by Struve in 1830. I have computed the orbit by the Glasenapp-Kowalsky method, and find the following provisional elements:—

Elements of Σ 2525.

P = 138·54 years.	$\Omega = 78°\ 19'{\cdot}5$
T = 1887·12	$\lambda = 4°\ 19'$
$e = 0{\cdot}802$	$a = 0''{\cdot}75$
$i = 54°\ 0'$	$\mu = -2°{\cdot}5984$

The following is a comparison between the measures used in calculating the orbit and the positions computed from the above elements. Some of the measures are rather discordant.

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
		°	°	°	″	″	″
1830·43	Struve	255·9	257·3	−1·4	1·33	1·32	+0·01
1836·14	,,	255·5	255·5	0·0	1·30	1·28	+0·02
1840·56	O. Struve	251·8	254·1	−2·3	1·04	1·24	−0·20
1840·62	Dawes	255·5	254·1	+1·4	1·25	1·24	+0·01
1840·70	O. Struve	252·4	254·1	−1·7	1·28	1·24	+0·04
1840·84	,,	253·1	254·0	−0·9	1·52	1·24	+0·28
1842·41	Mädler	251·0	253·5	−2·5	0·82	1·21	−0·39
1843·69	,,	254·0	253·1	+0·9	0·95	1·20	−0·25
1854·63	O. Struve	246.8	248·5	−1·7	1·05	1·05	0·0
1856·61	Secchi	247·1	247·7	−0·6	0·85	1·01	−0·16
1865·22	Dembowski	240·8	242·3	−1·5	0·60	0·81	−0·21
1865·48	Engelmann	253·6	242·2	(+11·4)	0·73	0·80	−0·07
1865·64	Secchi	239·9	242·1	−2·2	0·40	0·80	−0·40
1865·76	O. Struve	241·5	242·0	−0·5	0·74	0·80	−0·06
1865·80	,,	242·4	242·0	+0·4	0·73	0·80	−0·07
1872·61	,,	234·0	234·8	−0·8	0·66	0·60	+0·06

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
		°	°	°	"	"	"
1872·64	Wilson and Seabroke	232·6	234·8	−2·2	...	0·60	
1873·54	Ferrari	241·1	233·4	+7·7	...	0·57	
1873·57	„	225·8	233·3	−7·5	0·5	0·57	−0·07
1873·61	Dembowski	233·4	233·3	+0·1	0·6	0·57	+0·03
1873·65	Wilson and Seabroke	232·1	233·3	−1·2	...	0·57	
1874·75	„ „	237·8	231·2	+6·6	0·5	0·53	−0·03
1874·84	Gledhill	234·2	231·0	+3·2	0·48	0·52	−0·04
1875·65	Schiaparelli	232·1	229·4	+2·7	0·45	0·49	−0·04
1875·66	Wilson and Seabroke	233·6	229·4	+4·2	...	0·49	
1877·01	Schiaparelli	230·1	225·9	+4·2	0·37	0·43	−0·06
1877·82	Dembowski	238·0	223·7	(+14·3)	...	0·41	
1879·71	Hall	213·2	216·1	−2·9	0·33	0·32	+0·01
1880·61	Doberck	218·85	210·8	+8·05	...	0·28	
1880·67	Schiaparelli	217·8	210·5	+7·3	0·32	0·28	+0·04
1880·81	Doberck	201·16	209·8	−8·64	...	0·28	
1887·7	Schiaparelli	Single with 18-inch refractor				0·15	
1891·40	Burnham	343·4	342·8	+0·6	0·18	0·18	0·0
1892·422	„	328·3	328·3	0·0	0·27	0·21	+0·06

Assuming that the mass of the system is equal to the mass of the Sun, the "hypothetical parallax" would be

$$p = \frac{a}{P^{\frac{2}{3}}} = 0''{\cdot}028.$$

The magnitudes of the components are, according to Struve, 7·4, 7·6; and the approximate position of the star for 1880·0 is

R.A. $19^h\ 21^m{\cdot}7$

Decl. $+27°\ 8'$

It lies about $1\frac{1}{4}°$ *s.p.* *β Cygni.*

The Orbit of γ Coronæ Australis. By R. P. Sellors, B.A.

(*Communicated by H. C. Russell, B.A., F.R.S.*)

The general equation of the apparent ellipse was found by Glasenapp's method, and the geometrical elements deduced therefrom by the formulæ of Kowalsky. The dynamical elements were determined from five equations of mean motion.

Elements.

P = 121·24 years	$\Omega = 57°\ 57'$
T = 1879·33	$\lambda = 181°\ 5'$
$e = 0{\cdot}33096$	$a = 2''{\cdot}191$
$i = 35°\ 37$	$\mu = -2°{\cdot}9694$

The following is a comparison between all the measures I have been able to collect, and the positions computed from the above elements:—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	No. of Nights.	ρ_o	ρ_c	$\rho_o - \rho_c$	No. of Nights.
		°	°	°		"	"	"	
1834·47	Herschel	37·1	37·9	−0·8	1				
35·55	„	36·8	36·2	+0·6	2				
36·43	„	34·5	34·9	−0·4	1				
37·21	„	...	...	...	...	2·66	2·61	+·05	6
37·43	„	32·7	33·3	−0·6	4				
47·32	Jacob	14·1	14·7	−0·6	2	2·30	2·21	+·19	2
50·46	„	5·9	7·1	−1·2	...	2·29	2·07	+·22	
51·54	„	4·5	4·3	+0·2	...	2·26	2·02	+·24	
52·49	„	2·2	1·7	+0·5	...	1·90	1·97	−·07	
53·52	„	359·1	358·7	+0·4	...	1 83	1·92	−·09	
53·708	Powell	358·6	358·1	+0·5	4				
54·26	Jacob	356·2	356·5	−0·3	3	1·71	1·89	−·18	2
54·782	Powell	355·6	354·9	+0·7	3				
55·768	„	352·9	351·7	+1·2	5				
56·441	Jacob	349·4	349·4	0·0	11	1·67	1·79	−·12	11
57·434	„	347·4	345·9	+1·5	8	1·61	1·75	−·14	8
58·200	„	343·4	343·1	+0·3	3	1·53	1·71	−·18	3
59·721	Powell	338·1	337·3	+0·8	4				
61·691	„	328·8	329·0	−0·2	4				
62·271	„	325·3	326·4	−1·1	5				
63·836	„	318·1	319·1	−1·0					
70·19	„	286·9	286·7	+0·2					
75·648	Schiaparelli	257·4	258·0	−0·6	4	1·45	1·45	·00	4
76·645	Howe	253·1	252·8	+0·3	1	1·67	1·46	+·21	1
77·430	Schiaparelli	248·4	248·7	−0·3	5	1·49	1·46	+·03	3
77·611	Howe	245·7	247·7	−2·0	3	1·37	1·46	−·09	3
77·687	Stone	249·4	247·3	+2·1	1				
78·491	Howe	242·9	243·2	−0·3	1	1·47	1·46	+·01	1
78·491	Stone	242·4	243·2	−0·8	1	1·22	1·46	−·24	1
79·695	Burnham	240·0	237·1	+2·9	1	0·87	1·47	−·60	1
80·457	Russell	233·1	233·2	−0·1	1	1·15	1·47	−·32	1
80·673	Hargrave	232·4	232·1	+0·3	1	1·32	1·47	−·15	1
81·720	Stone	225·5	226·8	−1·3	3	1·42	1·46	−·04	2
83·620	Wilson	217·7	217·0	+0·7	4	1·66	1·46	+·20	1
86·615	Pollock	200·6	201·5	−0·9	8	1·45	1·45	·00	8

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_o$	No. of Nights.	ρ_o	ρ_c	$\rho_o - \rho_c$	No. of Nights.
1886·704	Russell	203°·5	201°·0	+2°·5	1	1″·52	1″·45	+″·07	1
87·689	Pollock	196·6	195·9	+0·7	4	1·16	1·45	−·29	4
87·728	Tebbutt	196·2	195·7	+0·5	4	1·68	1·45	+·23	1
88·610	,,	189·3	191·1	−1·8	6	1·71	1·45	+·26	3
88·707	Leavenworth	188·0	190·6	−2·6	1				
89·41	Burnham	185·4	186·9	−1·5	4	1·79	1·45	+·34	4
89·837	Tebbutt	185·4	184·7	+0·7	4	2·30	1·45	+·85	1
90·589	,,	183·0	180·8	+2·2	4	1·61	1·46	+·15	4
90·647	Sellors	180·5	180·5	0·0	6	0·99	1·46	−·47	4
91·676	,,	177·6	175·2	+2·4	4	1·33	1·47	−·14	3
91·711	Tebbutt	176·3	175·0	+1·3	9	1·53	1·47	+·06	4

Government Observatory, Sydney, New South Wales:
1892 September 5.

Observations of Brooks' Comet (d 1892) and Swift's Comet (a 1892) made at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The observations were made with the East, or Sheepshanks equatoreal, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power, 55.

Brooks' Comet.

Greenwich Mean Solar Time.	Observer.	☄ − ✱ R.A.	Log factor of Parallax.	Corr. for Refraction.	☄ − ✱ N.P.D.	Log factor of Parallax.	Corr. for Refraction.	No. of Comps.	Appt. R.A.	Appt. N.P.D.	Comp. ✱
1892 d h m s		m s		s	′ ″		″		h m s	° ′ ″	
Sept. 24 12 18 58	A. C.	+0 23·98	9·6160	−0·01	− 2 36·3	0·8100	−0·3	4	7 9 37·86	61 52 14·7	*a*
Oct. 1 12 12 31	L.	+0 36·63	9·6091	+0·05	+ 8 2·2	0·8148	+0·5	2	...	...	*b*
1 12 53 32	,,	+0 33·63	9·6133	−0·04	−13 2·1	0·7848	+0·1	2	...	...	*c*
1 12 18 2	B.	+0 37·75	9·6106	+0·05	+ 7 43·7	0·8106	+0·3	2	...	...	*b*
1 12 45 34	,,	+0 33·63	9·6135	−0·04	−13 19·1	0·7904	+0·1	2	...	...	*c*
14 12 53 23	,,	+0 6 38	9 5965	−0·03	− 8 55·2	0·7955	−0·2	2	8 11 41·90	68 20 24·4	*d*
14 12 57 2	,,	+0 44·38	9·5960	−0·03	− 8 37·8	0·7934	−0·2	2	8 11 42·67	68 20 33·8	*e*
14 13 1 33	,,	+1 15·00	9·5951	−0·02	− 5 34·7	0·7906	−0·2	2	8 11 43·48	68 20 39 0	*f*
14 13 4 35	,,	−0 59·00	9·5944	+0·03	+10 58·2	0·7887	+0·1	2	8 11 38·12	68 21 9·2	*g*
14 13 19 22	C. D.	−0 57·00	9·5898	+0·03	+11 1·9	0·7793	+0·1	2	8 11 40·12	68 21 12·9	*g*
14 13 25 26	,,	+1 17·00	9·5874	−0·01	− 5 13·8	0·7756	−0·1	2	8 11 45·49	68 21 0·0	*f*
14 13 29 26	,,	+0 48·25	9·5857	−0·02	− 8 25·6	0·7730	0·0	2	8 11 46·55	68 20 46·2	*e*
14 13 32 24	,,	+0 11·63	9·5843	−0·02	− 8 23·9	0·7711	0·0	2	8 11 47·16	68 20 55·9	*d*
18 13 12 58	,,	−0 10·19	9·5857	+0·01	+ 2 24·9	0·7897	+0·1	8	...	...	*h*
22 12 15 42	H.	−1 5·50	9·5858	+0·13	+11 34·5	0·8246	−0·1	4	8 39 19·70	72 18 3·7	*i*

Greenwich Mean Solar Time.					Observer.	☄ − ★ R.A.	Log factor of Parallax.	Corr. for Refraction.	☄ − ★ N.P.D.	Log factor of Parallax.	Corr. for Refraction.	No. of Comps.	Appt. R.A.	Appt. N.P.D.	Cmp. ★
1892	d	h	m	s		m s		s	′ ″		′		h m s	° ′ ″	
Oct.	22	12	29	0	H.	−2 40·25	9·5871	+0·05	+ 6 7·9	0·8182	−0·2	1	...	...	*k*
	22	12	58	7	,,	+0 40·38	9·5836	−0·04	− 7 32·3	0·8041	+0·7	4	...	...	*l*
	22	12	58	59	C. D.	−1 1·00	9·5840	+0·06	+12 44·1	0·8038	−1·3	3	8 39 24·13	72 19 12·1	*i*
	22	13	15	38	,,	+0 43·25	9·5791	−0·02	− 6 51·2	0·7955	+0·9	2	...	...	*l*
	23	12	19	0	A. C.	+0 26·15	9·5851	+0·09	+ 8 19·0	0·8242	+0·2	4	...	...	*m*
	23	12	27	19	,,	+1 12·83	9·5857	−0·13	−13 39·6	0·8203	0·0	2	...	...	*n*
	23	12	27	19	,,	+0 10·40	9·5857	+0·05	+ 4 45·7	0·8203	−0·1	2	...	...	*o*
	25	13	34	13	B.	−0 46·87	9·5652	−0·04	−11 41·8	0·7930	−0·2	5	8 50 28·50	74 4 8·1	*p*
	25	13	36	27	,,	−1 9·39	9·5647	+0·01	+ 4 37·5	0·7921	+0·1	7	8 50 25·80	74 4 54·5	*q*
Nov.	3	14	3	49	A. C.	−1 0·30	9·5345	−0·01	− 3 34·4	0·8074	−0·1	3	...	...	*r*
	3	14	19	21	,,	+2 30·90	9·5203	−0·03	−11 36·7	0·8035	−0·1	1	9 25 13·17	80 16 48·5	*s*
	3	14	9	42	T. H.	−0 58·45	9·5300	−0·01	− 3 27·8	0·8061	−0·1	2	...	...	*r*
	6	13	48	31	B.	+0 57·75	9·5440	−0·03	− 7 56·4	0·8195	−0·3	3	9 37 20·54	82 38 37·5	*t*
	6	13	55	38	,,	−3 7·80	9·5390	−0·03	− 8 37·8	0·8181	−0·2	3	9 37 22·20	82 39 1·3	*u*
	6	15	3	24	,,	+5 59·30	9·4632	0·00	+ 0 48·6	0·8062	0·0	3	9 37 31·69	82 41 40·6	*v*

Swift's Comet.

1892	d	h	m	s		m s		s	′ ″		″		h m s	° ′ ″	
Oct.	23	10	58	51	A. C.	−0 21·65	9·2376	0·00	−14 57·0	0·2583	−0·1	2	23 47 14·11	48 59 58·6	*w*

Notes.

On Oct. 23 Swift's Comet was extremely faint and was only suspected; its close proximity to several faint stars increased the difficulty of accurate observation.

Brooks' Comet on Oct. 23 was large and round, with decided central condensation.

On Nov. 3 it was very faint owing to moonlight and mist. On Nov. 6 it was noted as fairly large, with a nucleus of 7·5 magnitude.

Assumed Mean Places of Comparison Stars.

Star's Name.	Mean R.A., 1892·0. h m s	Mean N.P.D., 1892·0. ° ′ ″	Authority.
a. 53 Geminorum	7 9 12·24	61 54 54·0	Paris Catalogue.
b. B.D. + 26° 1605	7 29 32·4	63 33·4	Bonn Observations.
c. B.D. + 26° 1607	7 29 45·9	63 54·4	,, ,,
d. W.B. (2) VIII.. 192	8 11 33·69	68 29 20·2	Weisse's Bessel.
e. W.B. (2) VIII., 173	8 10 56·46	68 29 12·3	,, ,,
f. Lalande, 16149	8 10 26·63	68 26 14·4	Paris Catalogue.
g. Lalande, 16236	8 12 35·23	68 10 11·1	,, ,,
h. B.D. + 19°, 2026	8 25 28·7	70 11·2	Bonn Observations.
i. Lalande 17260	8 40 23·18	72 6 28·4	Lalande.
k. B.D. + 17°, 1941	8 41 59	72 12·1	Bonn Observations.
l. B.D. + 17°, 1931	8 39 56	72 31·8	,, ,,
m. B.D. + 17°, 1943	8 42 24	72 44·0	,, ,,
n. B.D. + 17°, 1939	8 41 42	73 6·2	,, ,,
o. B.D. + 17°, 1945	8 42 42	72 46·7	,, ,,
p. o_1 Cancri	8 51 13·52	74 15 49·0	Greenwich Ten-Year Catalogue, 1880
q. o_2 Cancri	8 51 33·29	74 0 15·7	,, ,, ,,
r. B.D. + 9°, 2195	9 26 7·8	80 20·4	Bonn Observations.

Star's Name.	Mean R.A., 1892·0.	Mean N.P.D., 1892·0.	Authority.
	h m s	° ′ ″	
s. ω Leonis	9 22 40·41	80 28 23·2	Greenwich Ten-Year Catalogue, 1880, and Paris Catalogue.
t. Lalande, 19042	9 36 20·95	82 46 31·7	Paris Catalogue.
u. B.F., 1383	9 40 28·18	82 47 36·5	Greenwich Ten-Year Catalogue, 1880.
v. 10 Leonis	9 31 30·49	82 40 49·7	,, ,, ,,
w. Groombridge, 4155	23 47 33·08	49 15 19·6	Radcliffe Catalogue.

The following observations of Swift's Comet were made on the meridian with the Transit Circle:—

Greenwich Mean Solar Time.	Observer.	Appt. R.A.	Appt. N.P.D. (Corrected for Refraction and Parallax.)
1892. d h m s		h m s	° ′ ″
Sept. 17 12 30 53	A. C.	0 20 27·72	39 28 17·81
Sept. 24 11 54 34	,,	0 11 39·10	40 55 18·44

The corrections applied for parallax were 0″·06, 0″·17 respectively.

In computing these log Δ was taken as 0·2819 on September 17, 0·2907 on September 24, these values being interpolated from Archenhold's Ephemeris (*Astr. Nach.*, 3110).

On September 24 the comet was very faint, and was observed over one wire only in R.A.

The initials L., H., A. C., B., T. H., C. D., are those of Mr. Lewis, Mr. Hollis, Mr. Crommelin, Mr. Bryant, Mr. Hudson, and Mr. Davidson respectively.

Assumed Mean Places of Comparison Stars.

Star's Name.	Mean R.A., 1892·0. h m s	Mean N.P.D., 1892·0. ° ′ ″	Authority.
a. 53 Geminorum	7 9 12·24	61 54 54·0	Paris Catalogue.
b. B.D. + 26° 1605	7 29 32·4	63 33·4	Bonn Observations.
c. B.D. + 26° 1607	7 29 45·9	63 54·4	,, ,,
d. W.B. (2) VIII.. 192	8 11 33·69	68 29 20·2	Weisse's Bessel.
e. W.B. (2) VIII., 173	8 10 56·46	68 29 12·3	,, ,,
f. Lalande, 16149	8 10 26·63	68 26 14·4	Paris Catalogue.
g. Lalande, 16236	8 12 35·23	68 10 11·1	,, ,,
h. B.D. + 19°, 2026	8 25 28·7	70 11·2	Bonn Observations.
i. Lalande 17260	8 40 23·18	72 6 28·4	Lalande.
k. B.D. + 17°, 1941	8 41 59	72 12·1	Bonn Observations.
l. B.D. + 17°, 1931	8 39 56	72 31·8	,, ,,
m. B.D. + 17°, 1943	8 42 24	72 44·0	,, ,,
n. B.D. + 17°, 1939	8 41 42	73 6 2	,, ,,
o. B.D. + 17°, 1945	8 42 42	72 46·7	,, ,,
p. o_1 Cancri	8 51 13·52	74 15 49·0	Greenwich Ten-Year Catalogue, 1880
q. o_2 Cancri	8 51 33·29	74 0 15·7	,, ,, ,,
r. B.D. + 9°, 2195	9 26 7·8	80 20·4	Bonn Observations.

Star's Name.	Mean R.A., 1892·0.	Mean N.P.D., 1892·0.	Authority.
	h m s	° ′ ″	
s. ω Leonis	9 22 40·41	80 28 23·2	Greenwich Ten-Year Catalogue, 1880, and Paris Catalogue.
t. Lalande, 19042	9 36 20·95	82 46 31·7	Paris Catalogue.
u. B.F., 1383	9 40 28·18	82 47 36·5	Greenwich Ten-Year Catalogue, 1880.
v. 10 Leonis	9 31 30·49	82 40 49·7	,, ,, ,,
w. Groombridge, 4155	23 47 33·08	49 15 19·6	Radcliffe Catalogue.

The following observations of Swift's Comet were made on the meridian with the Transit Circle:—

Greenwich Mean Solar Time.	Observer.	Appt. R.A.	Appt. N.P.D. (Corrected for Refraction and Parallax.)
1892. d h m s		h m s	° ′ ″
Sept. 17 12 30 53	A. C.	0 20 27·72	39 28 17·81
Sept. 24 11 54 34	,,	0 11 39·10	40 55 18·44

The corrections applied for parallax were 0″·06, 0″·17 respectively.

In computing these log Δ was taken as 0·2819 on September 17, 0·2907 on September 24, these values being interpolated from Archenhold's Ephemeris (*Astr. Nach.*, 3110).

On September 24 the comet was very faint, and was observed over one wire only in R.A.

The initials L., H., A. C., B., T. H., C. D., are those of Mr. Lewis, Mr. Hollis, Mr. Crommelin, Mr. Bryant, Mr. Hudson, and Mr. Davidson respectively.

Observations of Holmes' Comet (f 1892) made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East, or Sheepshanks Equatoreal, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power, 55.

Greenwich Mean Solar Time.	Observer.	✓ − ✱ R.A.	Log factor of Parallax.	Corr. for Refraction.	✓ − ✱ N.P.D.	Log factor of Parallax.	Corr. for Refraction.	No. of Comps.	Apparent R.A.	Apparent N.P.D.	Comp. ✱
1892. d h m s		m s		s	′ ″		″		h m s	° ′ ″	
Nov. 9 9 36 26	A. C.	−1 12·98	8·2200	0·00	+ 8 49·7	0·2983	+0·1	2	0 45 51·75	51 41 19·0	*a*
9 10 48 58	,,	−1 3·60	9·0446	0·00	+ 0 31·1	0·3542	0·0	3	...	...	*b*
9 11 22 53	,,	+1 22·40	9·3552	0·00	− 1 17·8	0·3818	0·0	2	0 45 53·02	51 41 29·6	*c*
10 6 17 48	L.	+1 17·13	9·5314	0·00	− 4 39·0	0·4866	−0·1	2	0 45 26·34	51 45 54·8	*d*
10 6 17 48	,,	−1 41·25	9·5314	−0·01	+13 43·0	0·4866	+0·1	2	0 45 23·46	51 46 12·2	*a*
10 6 25 3	A. C.	+1 18·33	9·5177	0·00	− 4 42·1	0·4751	−0·1	2	0 45 27·54	51 45 51·7	*d*
10 6 14 43	,,	−1 30·15	9·5368	0·00	+ 5 15·8	0·4903	+0·1	1	...	...	*b*

Comparison Stars.

	Star's Name.	R.A. 1892·0. h m s	N.P.D. 1892·0. ° ′ ″	Authority.
a	Lalande, 1444	0 47 1·73	51 32 55·0	Paris Catalogue, 1875.
b	B.D. + 38°, 128	0 46 51·3	51 40·5	Bonn Observations.
c	W. B. (2), 0, 1092	0 44 27·63	51 43 13·2	Weisse's Bessel.
d	W. B. (2), 0, 1083	0 44 6·22	51 50 59·8	,, ,,

Note.

The comet was very bright, about 5′ in diameter, with a stellar nucleus.

The initials L. and A. C. are those of Mr. Lewis and Mr. Crommelin respectively.

Royal Observatory, Greenwich:
1892 *November* 11.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. DECEMBER 9, 1892. No. 2

E. B. KNOBEL, President, in the Chair.

John A. Brashear, Allegheny, Pennsylvania, U.S.A.;
Walter William Bryant, Seymour Cottage, Conduit Vale, Blackheath, S.E.;
Captain James Fisher, Kentmere, Birdhurst Rise, South Croydon;
Thomas Charlton Hudson, 3 Montpelier Row, Blackheath, S.E.;
Francis R. Wardle, 43 Moorgate Street, E.C.,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Harold John Adams, M.A., Civil Servant, St. John's, Cedar Road, Beckenham (proposed by John M. Stone);
Samuel Barker, Barrister-at-law, 9 Hanover Terrace, Regent's Park, N.W. (proposed by Arthur Kennedy);
P. Doyle, F.R.S.E., M.R.I.A., Editor of *Indian Engineering*, 19 Lall Bazar, Calcutta (proposed by Asutosh Mukhopadhyay);
The Rev. Edwin G. Gange, Baptist Minister, Osborne House, Cotham Park, Bristol (proposed by W. F. Denning);
John Spencer, F.G.S., Rock House, Crawshaw Booth, near Manchester (proposed by William Garnett);
Anthony Stanbridge Thomson, Lieut. R.N.R., F.R.G.S., F.R.M.S., A.I.E.E., Telegraph Works, Silvertown, Essex (proposed by Charles Bright).

Seventy-one presents were announced as having been received since the last meeting, including, amongst others, Zeichnungen und Studien des Mondes, von Dr. L. Weinek, presented by the Prague Observatory; Second Glasgow Catalogue of 2,156 stars for the epoch 1890 . . . by Professor Robert Grant, presented by the Glasgow Observatory; The Visible Universe, by J. E. Gore, presented by the publishers; J. Mabillon, Iter Germanicum, Hamburgi 1717, presented by the President.

Note on Nova Aurigæ. By W. H. M. Christie, Astronomer Royal.

The *Nova* appears to have again brightened recently after having become invisible during October in the 10-inch guiding telescope of the Astrophotographic Equatorial, and several photographs have been taken of it lately, comparisons with the companion star about 2′ n.f. having been also made by eye with the 10-inch refractor. In this telescope it was noted as invisible about October 7 by Mr. Turner (who saw the companion star distinctly), on October 22 by Mr. Davidson, and on October 25 by Miss Everett. Mr. Davidson again looked for it on November 29, and was surprised to find it decidedly brighter visually than the companion star, and on November 30 Mr. Turner and Mr. Davidson both estimated it as about one magnitude *brighter* than the companion. As this star was estimated by Professor Krueger, in his Revisionzone, 1858 March 23, to be of 9·5 mag., the visual magnitude of the *Nova* as estimated by Mr. Turner and Mr. Davidson on November 30 would be about 8·5 mag.

From photographs taken by Mr. Davidson on November 29 and 30, and by Miss Russell on December 5, with exposures ranging from 16^m to 15^s, the *Nova* appears to be photographically about 0·9 mag. *fainter* than the companion star, the photographic magnitude of the *Nova* referred to the four companion stars (8·2 to 8·7 mag.) being 11·6, while that of the companion is 10·7 mag.

Thus while the *Nova* is now visually about 1 mag. *brighter* than the companion star, it is photographically nearly 1 mag. *fainter*; and it is to be noted that the companion star is photographically about 1 mag. fainter than Professor Krueger's visual estimate, so that it would seem that the *Nova* is now about three magnitudes fainter photographically than visually.

Royal Observatory, Greenwich:
1892 *December* 8.

On the Spectrum of the New Star in Auriga, as compared with the spectra of planetary nebulæ. By Eugen von Gothard.

In the new star, which appeared in February, a catastrophe took place before our eyes, which is perhaps destined to afford us a glimpse into the origin and the disappearance of celestial bodies. My spectrographic studies seem to show me the direction in which to look for the origin and the dissolution of stars.

In February I examined the spectrum of the new star several times directly by the eye, and six times by means of photography.

The spectrum consisted of many bright and several dark lines, the latter mostly corresponding with the former. My photographs show 40–43 bright lines and 12–13 dark ones.

It appeared to me, therefore, as if it consisted of two bodies, of which the one produced the emission, the other the absorption spectrum, and which had rushed against each other with enormous rapidity in the line of sight.

I will refrain on this occasion from entering into a minute description of the beautiful spectrum. The following remarks treat merely of its present aspect.

The new star rapidly decreased in brilliancy. After the middle of March I could not observe it with my modest 10½-inch reflector. In the autumn, when it was again in a favourable position for observation, I observed it with a beautiful 10-inch objective prism, which my friend Dr. Nicholas von Konkoly had placed at my disposal for my spectrographic studies. The valuable prism had been ground by a very skilful amateur, Herr Fabriksdirector Dr. Max Pauly in Mühlberg.

The spectrum appeared amongst the numerous spectra of the neighbouring stars like a star of the 10th mag. It was therefore monochromatic.

I obtained a photograph of it on September 15. As I did not find it on the plate I took another on the 19th. This time six spots could be distinguished.

In the meantime I had photographed with the prism several interesting but seldom accessible objects, so that a comparison with the nebulæ G.C. No. 4447, 4964, and with the Wolf-Rayet stars in *Cygnus*, became possible. My surprise was very great to find that the spectrum of the *Nova* bore a great resemblance to the two first-mentioned nebulæ. Since then I have taken the photographs of several planetary nebulæ, not only with the objective prism, but also with my quartz iceland spar spectrograph, so that I could determine the wave-lengths of the spots. Each new photograph increased the probability, which may be considered as a proved fact, that *the spectrum not only resembles, but that the aspect and the position of the lines show it to be identical with the spectra of the planetary nebulæ.* In other words, the new star has changed into a planetary nebula.

The following table will demonstrate my assertion in the most striking manner:—

	Wave-lengths.						
	I.	II.	III.	IV.	V.	VI.	VII.
G.C. No. 4447	502	...	434	411	396·5	386	373 μμ
G.C. No. 4964	501	470	434	409	397	386·5	...
G.C. No. 4373	502	...	434	410	396·5	386·5	373
G.C. No. 4514	502	...	434	410	396·5	386·7	371
G.C. No. 4628	501	468	434	408 5	396	386·5	372
N.G.C. No. 7027	500·7	464	434	410	395	385 5	...
N.G.C. No. 6891	502	...	434	410	396	386	372
N.G.C. No. 6884	500·5	...	434	...	395	386·5	...
New star 580(?)	500	465	434	408	395	385·5	372

The correspondence of the wave-lengths is so close that one could not expect it to be closer, considering the uncertainty of the measurement of the diffused spots, and the shortness of the entire spectrum, the whole lengths, from λ500 to λ372, being only 2·4 mm.

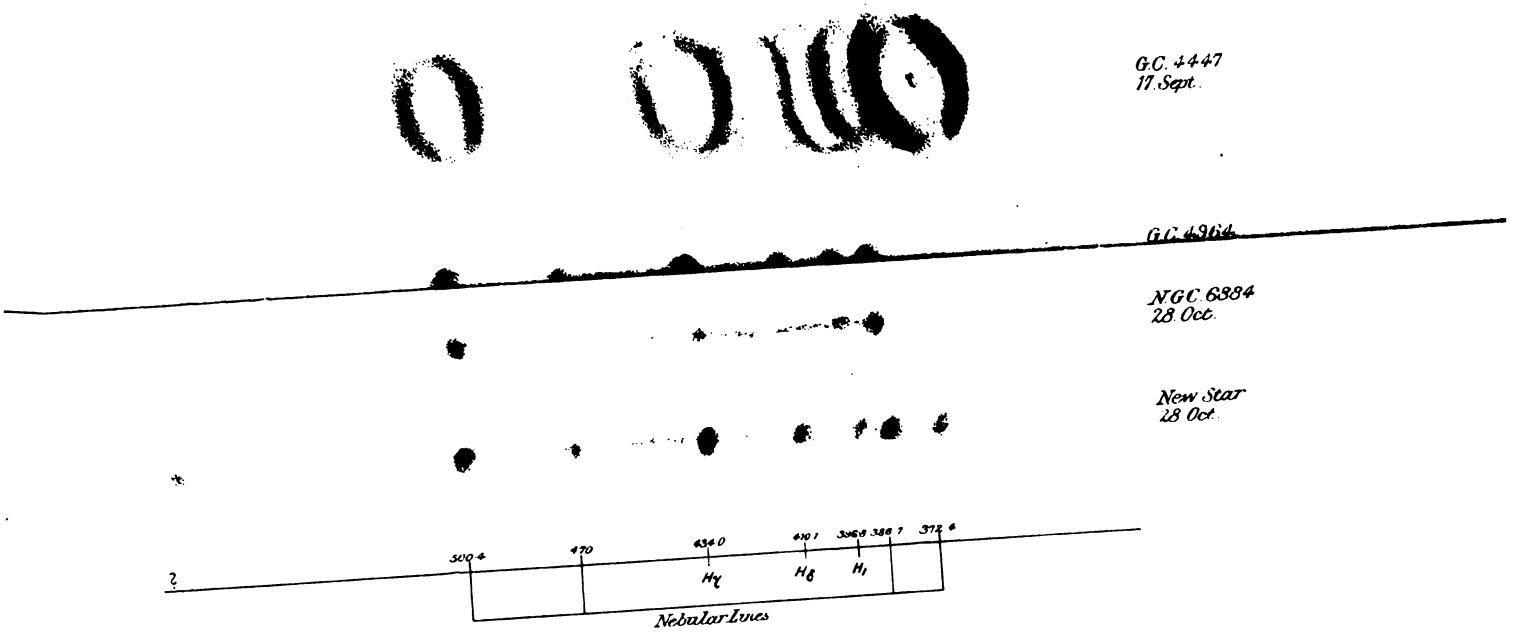
The resemblance between the spectra becomes most apparent and convincing when the plates are superposed and both spectra examined together side by side. Nobody could possibly distinguish one from the other.

Before entering into the details of the spectra I will note the estimated intensities:—

	I.	II.	III.	IV.	V.	VI.	VII.
G.C. No. 4447	8	...	5	2	6	7	10
G.C. No. 4964	8	2	9	6	6	10	...
G.C. No. 4373	5	...	10	7	7	9	4
G.C. No. 4514	3	...	10	7	6	9	5
G.C. No. 4628	9	1	6	4	5	10	1
N.G.C. No. 7027	10	1	6	1	2	8	...
N.G.C. No. 6891	6	...	8	5	4	10	1
N.G.C. No. 6884	9	...	5	...	1	10	...
New star	8	4	10	5	4	7	1

I must now communicate the results I arrived at with the quartz spectrograph, by means of which the identification of the lines and the computation of their wave-lengths became possible. No direct estimation is practicable with the objective-prism, since it is impossible to take with it simultaneously the photographs of the spectrum and of the comparison spectrum. But it would be quite as impossible to take with the spectroscope most of the above-mentioned nebulæ, on account of the great feebleness of their lights.

Monthly Notices of Royal Astronomical Society.



THE SPECTRUM OF THE NEW STAR IN AURIGA,
AS COMPARED WITH THE SPECTRA OF PLANETARY NEBULAE.

F. Gothard, phot. & del.

Great Nebula of Orion.

I.	1	II.	2	III.	IV.	V.
...	486·1	...	...	434·0	410·1	396·9
3	VI.		4	5	6	VII.
388·6	386·7		383·3	379·6	376·7	372·7

G.C. No. 4964.

I.	1	II.	2	III.	IV.	V.
500·8	...	469·0	436·0	434·0	410·1	396·9
3	VI.		4	5	6	VII.
388·9	386 8		...	379·7	...	...

G.C. No. 4628.

I.	1	II.	2	III.	IV.	V
500·9	...	...	...	434·0	410·1	396·6
3	VI.		4	5	6	VII.
388 7	386 7		...	...	...	...

Hydrogen.

I.	1	II.	2	III.	IV.	V.
...	486·1	...	...	434·01	410·10	396·89
3	VI		4	5	6	VII.
388·78	...		383·45	379·69	376·94	...

In the photograph of the *Orion* nebula, I. is missing, as an ordinary plate was used, and not, as for all the others, an orthochromatic one.

From these results the following final conclusions may be drawn :—

1. The spectra of the planetary nebulæ are very like each other ; they only differ somewhat in the relative intensities of the lines, which, however, do not alter their typical character.

2. The lines of hydrogen play so important a part that they are represented in all the spectra by several lines.

3. Besides the hydrogen lines, two characteristic nebular lines, $\lambda = 500{\cdot}8$ and $386{\cdot}7\mu\mu$. are found in all the nebulæ which I have so far examined ; the third line, $\lambda = 372{\cdot}4$, occurs frequently, but another line, $\lambda = 464$–$470\mu\mu$, appears but seldom.

4. The new star must, at present, be in a state which chemically and physically resembles that of the planetary nebulæ.

5. In the spectra of all planetary nebulæ there exists a more or less distinct continuous spectrum, which seems to form the nucleus of the nebula. The spectrum gives the impression that this nucleus is surrounded by an extensive gaseous atmosphere.

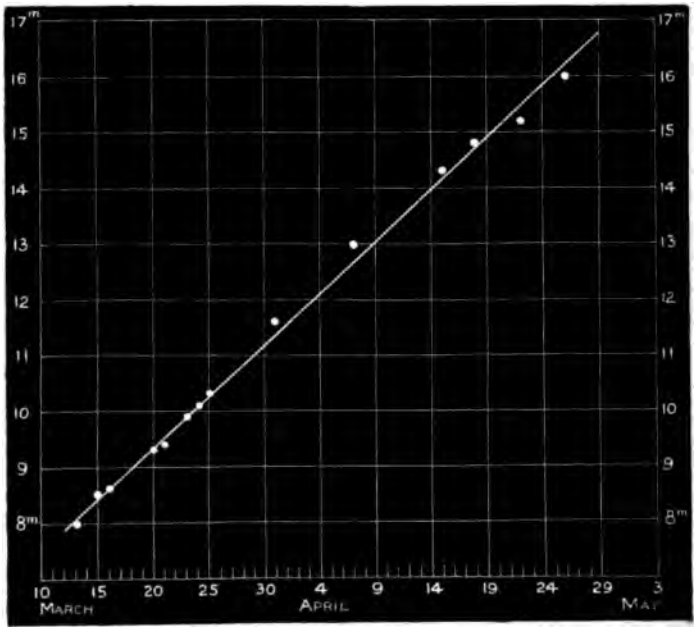
I will not draw any further conclusions at present, but will continue my studies, and shall especially endeavour, by means of long exposures, to obtain with greater certainty such details as are not sufficiently distinct as yet.

I shall pursue the history of the new star further by photographing its spectrum from time to time, and hope that I may take the liberty of giving another account of my results.

Herény Astrophysical Observatory,
1892 *November* 4.

The New Star in Auriga. By S. W. Burnham, M.A.

My observations of Anderson's new star in *Auriga*, which connected it by micrometrical measures with all of the stars within a radius of about 2′, have been given in *Monthly Notices* for April 1892. These measures were principally made while the new star was as bright as the sixth magnitude. After it had fallen to the eighth magnitude, I commenced a series of observations with a view of ascertaining its magnitude, and the ratio of



Observed Magnitudes of the New Star in *Auriga*.

diminution, during the time of its change, or so long as it might be visible with the large refractor of the Lick Observatory. I observed it on every available occasion until it was so low in the west in the early part of the evening that further comparisons would have little or no value.

For the lower magnitudes I have used for comparison the same stars which had been measured previously, and have adopted the magnitudes there given in determining that of the new star, with the single exception of the nearest companion, B. When the measures were made, the new star was a naked-eye object, and this faint companion at a distance of only 33″ was seen with considerable difficulty. The mean of the several estimates gave 14·8 for the magnitude of B. A careful examination of this star when the *Nova* had retrograded so that its light

could no longer affect the apparent brightness of the other, led me to think that this assigned magnitude was too small by about half a magnitude, and that it should be called 14·3. In the comparisons this value is used. I saw no reasons for changing the magnitudes previously given of the other companions.

In the following table I give the dates of the observations, the comparison stars used, the letters referring to the stars previously measured, and the deduced magnitude of the new star.

Observed Magnitudes of the New Star in Auriga.

Mar.	13	D. M. (30°) 942	8·0
	15	„ „ 913, 924, 942	8·5
	16	„ „ 913	8·6
	20	„ „ 913, 924	9·3
	21	„ „ 924	9·4
	23	F	9·9
	24	E, F, L, N	10·1
	25	L	10·3
	31	E, G, F	11·6
Apr.	7	E, G, I. J, B, K	13·0
	15	B	14·3
	18	B, C, *e*	14·8
	22	B, C	15·3
	26	B, C	16·0

The date last mentioned is the last time the new star was looked for. It was at that time very faint, and seen with considerable difficulty, but the conditions were not favourable. If the light continued to diminish as it had done throughout the observations, it was evident that, if it could be seen at all on any subsequent night, the estimates under the circumstances would have no value.

These observations are laid down on the accompanying diagram. It will be seen that the change in brightness from the eighth to the sixteenth magnitudes was perfectly uniform throughout. The divergences shown on the diagram are much within the ordinary errors of observation, and it is therefore safe to assume that the decline in brightness between these limits was without any sensible variation. This being true, there was every reason for supposing that the new star would go down steadily until it reached a point below the limit of the large telescope, and it is probable that this decline actually took place; but it could hardly have been anticipated that the star would again increase in brightness, and become a comparatively bright object in the course of a few months. It is unfortunate that it could not have been followed with the 36-inch until the

minimum brightness was reached, or until it was certainly beyond the reach of that instrument. In the scale of magnitudes employed here, that limit would have been reached in about a week from the date of the last observation. As the observations show that no change occurred in the rate of decrease while the star passed from the eighth to the sixteenth magnitude, and as it is probable that this movement would not be suddenly arrested, it is fair to presume that the new star became much fainter than the seventeenth magnitude, and passed far beyond the reach of any telescope.

It is also to be regretted that it was not examined earlier when it was again observable in the east. At this time, in the latter part of August, it seems to have reached about 10½ magnitude. This was followed by the important discovery by Professor E. E. Barnard, on the night of August 20, that it was no longer a star, but was a small bright nebula with a nucleus of about the tenth magnitude. The nebulous character of the object was seen at once by this experienced observer, with the ordinary micrometer eyepieces of the large equatoreal. The spectroscopic observations at Mount Hamilton and elsewhere have since shown a corresponding change in the spectrum.

I have been able to examine this star once since its reappearance. On the morning of September 6 it was observed by Professor George E. Hale and myself with the 12-inch of the Kenwood Observatory. At this time it was a little brighter than F, the comparison giving for the magnitude of the new star 10·2.

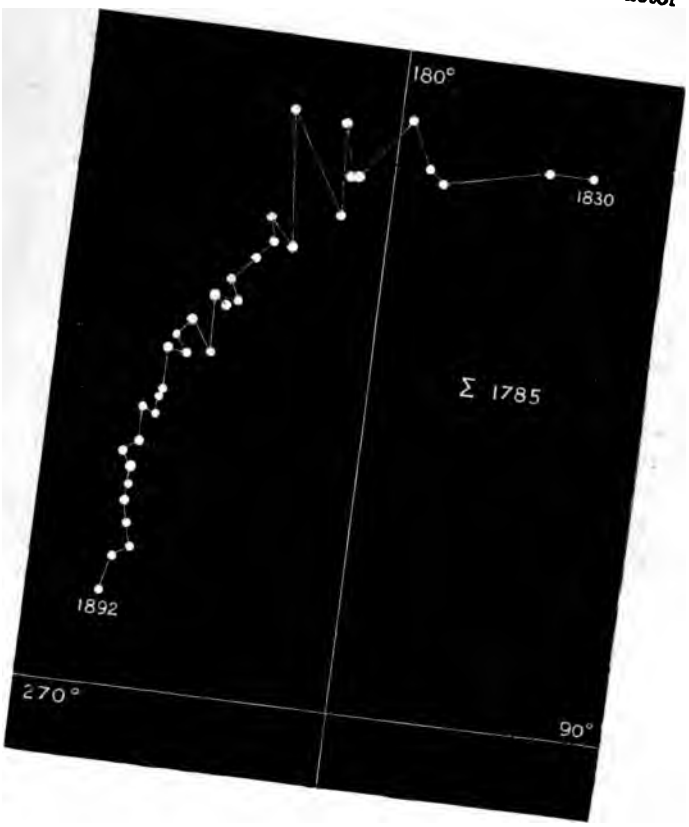
Chicago:
October 17.

The Binary Star Σ 1785. By S. W. Burnham, M.A.

This binary has now passed over 84° of position-angle since the measures of Struve in 1830; and the data are now sufficient for an approximate determination of the elements of the orbit. During this time the distance has been steadily diminishing. It was discovered by South, who measured it in 1823 on a single night. His distance is nearly 2″ too large, as will appear from a comparison with the later measures of Struve and others. It is evident that the period is a very long one, and that the angular change for some time to come will be comparatively rapid. It is therefore desirable that this pair should be measured every year or two for the present.

To facilitate the computation of the orbit, I have made a careful collection, from the original sources, of all the measures, and give them below in chronological order. The last observa-

tions cited were made recently with the 36-inch refractor of the Lick Observatory.



Measures of Σ 1785.

1823·40				
1830·12	160°·4	5″·66	South	1*n*
1830·20	164·4	3·49	Struve	3*n*
1831 ±	164·5	4·62	Herschel	1*n*
1831·34	163·8	3 ±	Herschel	1*n*
1833·48	166·3	(7·69)	Herschel	1*n*
1836 40	174·6	3·39	Mädler	2*n*
1839·44	176·2	3·19	Philpott	3*n*
1841·28	178·0	...	Mädler	4*n*
1841·32	178·7	3·48	Mädler	1*n*
	183·6	3·11	Mädler	2*n*
				2*n*

1856·31	183°·1	2″·97	Mädler	1*n*
1856 36	186·0	3·24	Secchi	2*n*
1858·38	185·1	3·12	Dembowski	5*n*
1859·32	185·4	2·89	Morton	2*n*
1861·57	190·0	3·51	Mädler	2*n*
1863·31	192·0	2·73	Radcliffe	2*n*
1863·68	191·1	2·66	Dembowski	11*n*
1864·47	193·5	2·88	Engelmann	2*n*
1865·42	193·8	2·87	Engelmann	7*n*
1865·82	193·3	2·59	Dembowski	11*n*
1867·40	196·1	2·81	O. Struve	2*n*
1867·83	195·8	2·52	Dembowski	8*n*
1870 19	198·6	2·54	Dunér	5*n*
1870·33	199·4	2·79	O. Struve	2*n*
1870·35	200·5	2·54	Gledhill	4*n*
1870·81	199 4	2·43	Dembowski	8*n*
1871·35	199·1	2·43	Radcliffe	2*n*
1871·38	199·2	2·51	Knott	3*n*
1871·43	199·9	2·38	Pierce	2*n*
1872·43	201·7	2·67	Dunér	2*n*
1872·89	201·9	2·32	Dembowski	8*n*
1873·42	200·2	2·41	Lindstedt	2*n*
1873·57	202·2	2·45	Wilson and Seabroke	4*n*
1874·79	205·2	2·18	Dembowski	7*n*
1875·24	206·4	2·47	Dunér	3*n*
1875·32	205·3	2·34	Schiaparelli	5*n*
1876·00	207·6	2·37	Wilson and Seabroke	4*n*
1876·41	208·6	2·56	Plummer	2*n*
1876·45	206·9	2·15	Schiaparelli	4*n*
1876·85	208·5	2·14	Dembowski	8*n*
1877 32	208 4	2·21	Doberck	6*n*
1877·38	208·6	2·25	Schiaparelli	6*n*
1878·34	210·5	2·14	Dembowski	3*n*
1878·39	210·7	2·55	Seabroke	2*n*
1879·42	214 5	2 04	Hall	3*n*
1879·46	212·5	2 20	Schiaparelli	5*n*
1879·50	214·0	2·07	Seabroke	3*n*
1880 35	215·9	1·92	Hall	2*n*
1880·37	213·8	2·13	Bigourdan	1*n*
1880·46	215·4	2·27	Jedrzejewicz	3*n*

1880·46	215°·2	2″·03	Seabroke	3*n*
1881·33	216·9	1·98	Bigourdan	1*n*
1881·36	217·9	2·11	Schiaparelli	4*n*
1881·40	215·7	1·96	Hough	1*n*
1881·40	217·8	1·92	Hall	2*n*
1882·42	219·9	1·93	Hall	3*n*
1882·44	220·0	2·13	Schiaparelli	7*n*
1882·45	221·3	2·22	Seabroke	3*n*
1882·46	221·9	2·22	Rugby	3*n*
1882·93	221·2	2·06	Engelmann	7*n*
1883·42	221·6	1·90	Hall	2*n*
1883·46	221·8	1·91	Schiaparelli	6*n*
1884·39	224·8	1·86	Hall	3*n*
1884·46	224·9	1·98	Schiaparelli	4*n*
1884·63	226·6	1·78	Rugby	2*n*
1885·35	223·8	1·86	Perrotin	3*n*
1885·36	226·8	1·78	Hall	3*n*
1885·43	227·9	1·72	Rugby	2*n*
1885·44	227·1	1·83	Schiaparelli	10*n*
1886·38	228·7	1·68	Perrotin	2*n*
1886·41	231·4	1·46	Rugby	2*n*
1886·41	228·0	1·83	Hall	3*n*
1887·37	232·7	1·62	Hall	3*n*
1887·45	231·8	1·67	Schiaparelli	11*n*
1887·45	232·8	1·08	Rugby	1*n*
1887·59	228·0	1·80	Tarrant	2*n*
1888·33	236·5	1·12	Rugby	3*n*
1888·37	233·9	1·61	Hall	3*n*
1889·28	235·3	1·60	Rugby	3*n*
1889·45	237·1	1·51	Hall	3*n*
1890·43	240·7	1·54	Hall	3*n*
1890·47	240·5	1·57	Hayn	1*n*
1892·37	248·6	1·46	Burnham	3*n*

The character of the relative motion will be best seen from the accompanying diagram showing the observed positions for each year in which measures were made. The observations of South in 1823, and those of Herschel in 1830–31, are omitted, as they are obviously erroneous in distance. The diagram strikingly illustrates, even with these omissions, the superior accuracy and consistency of the later measures, although the

components were much closer, and more difficult to observe. Where the years are represented by the measures of more than one observer, the mean is taken for the position shown on the diagram.

The interest of this pair is further increased by the proper motion of the system. This is given by Stumpe from Argelander as 0″·481 in the direction of 262°·95.

The place of this star (1880) is:

R.A. $13^h\ 43^m\ 38^s$
Decl. + 27° 35′

Chicago: November 20.

The Lunar Eclipse, 1892 *May* 11–12. By G. J. Newbegin.

The night of May 11–12 turned out so exceptionally fine and clear that (though in −16° of declination) the Moon soon became a steady object in the telescope.

With regard to the eclipse, I decided to take a series of photos at about half-hour intervals, and so endeavour to secure a permanent record of its several stages.

The exposures were made at 9 20, 9.50, 10 30, 11, 11.30 P.M., 12 midnight, and 12.30 A.M.

The periods of exposure were varied to allow for the decreasing illumination of the Moon, and were respectively 20^s, 20^s, 30^s, 40^s, 30^s, 20^s, 20^s.

The plates were the Ilford Ordinary, developed by hydroquinone.

The instrument by which they were taken is a 9-inch Cooke Equatoreal, aperture reduced to two inches for the whole series.

The intervals between the exposures were occupied in developing the plates.

1892 *November* 11.

Note on an Occultation of DM.+4°.123 (*Mag.* 6·5) *by Mars on* 1893 *January* 14. By A. M. W. Downing, M.A.

Amongst the cases of possible occultations of stars by planets, given by Herr Berberich in *Ast. Nach.*, No. 3131, is one of the occultation of a 6·5 mag. star by *Mars* on January 14 next. The star will be occulted to observers situated at the Cape and at Durban; and the particulars of the occultation are given below for these observatories, as well as those of the near approach of the planet to the star as seen from Greenwich.

The star's place is taken from the Albany Zone Catalogue (where it is No. 204), the planet's from the *Nautical Almanac*, from which source are also taken the horizontal parallax and semi-diameter. The latter, as adopted in the *Nautical Almanac*, is undoubtedly too large—probably 0″·6 too large at the distance with which we are here concerned—so that the durations given below are probably too great in a corresponding proportion.

Cape Observatory. Middle of occultation January 14, $6^h\ 52^m{\cdot}9$ Cape mean time. Duration, $4^m{\cdot}9$. Position-angle at immersion, 50°. Position-angle at emersion, 260°. Unfortunately, the Sun does not set at the Cape on this day until $7^h\ 10^m$ Cape mean time.

Natal Observatory. Middle of occultation January 14, $7^h\ 43^m{\cdot}7$ Durban mean time. Duration, $4^m{\cdot}9$. Position-angle at immersion, 52°. Position-angle at emersion, 258°. At Durban the Sun sets on this day at $7^h\ 0^m$ Durban mean time.

Greenwich Observatory. Time of nearest approach, January 14, $5^h\ 40^m{\cdot}2$ Greenwich mean time. Distance of star from centre of planet at this time, 9″·8. Position-angle, 335°.

1892 *December* 9.

Photographs of Comet Holmes. By Isaac Roberts, D.Sc., F.R.S.

Two photographs of Comet Holmes have been taken with the 20-inch reflector. The first, on November 18 (last month) between sidereal time $0^h\ 30^m$ and $1^h\ 45^m$, with exposure of 75 minutes; and the second, on the 20th, with an exposure of 30 minutes. The one now presented is an enlargement from the first negative to the scale of 1 millimetre to 30 seconds of arc, the position of the comet then being, approximately, in R.A. $0^h\ 43^m$, Decl. N. 37° 24′.

The photograph shows the comet to be nearly circular in outline, with the n.p. semicircle well defined, but the s.f. side is undefined and shades into invisibility. The diameter of the defined part measures about 12 minutes of arc, and the comet has a well-defined stellar nucleus when viewed with a low magnifying power, but with a magnifying power of 77 diameters on the negative the nucleus is semi-transparent, and shades without a definite boundary into the comet.

From the nucleus projects a dense condensation, resembling a tail, about 6 minutes of arc in length and 80 seconds in breadth, extending in the n.p. to s.f. direction. The tail is straight, not sharply defined at the margins, and shades into invisibility. It ends with the undefined side, and forms a radius to the circle of the comet.

The nucleus measures about 23 seconds of arc in diameter, and 54 secs. preceding it is the star D.M. No. 140 Zone, 37°, R.A. $0^h\ 40^m\ 27^s$, Decl. 37° 11′·3, magnitude 9·5, epoch 1855.

The stellar nucleus of the comet, and the tail-like projection from it, are also well shown on the second photograph, with an exposure of 30 minutes.

Elements of Comet Holmes (*f* 1892). By Edward Roberts, F.S.S.

The following elements of the comet discovered by Mr. Holmes on November 6 have been calculated from the observations of November 9 and November 26, taken at the Royal Observatory, Greenwich, kindly communicated by the Astronomer Royal, and the position measured from a supposed photograph of the comet taken by Mr. Schooling, of Hammersmith, on October 18, between 8^h and $9^h\ 30^m$. The measurements of the photographic plate were made by Miss A. Russell.

Greenwich Mean Time.					Apparent R.A.			Apparent Decl.		
	d	h	m	s	h	m	s	°	′	″
Oct.	18	8	45		1	2	10·7	+39	55	54
Nov.	9	10	29	40	0	45	52·45	38	18	35·7
	26	9	7	56	0	42	9·8	+36	32	37

Epoch. 1892 Nov. 9·5 Greenwich Mean Time.

	°	′	″		
ϵ	341	49	6·3		
π	328	15	12·3	Mean Equinox of 1892·0	log a 0·7875307
ν	328	17	6 0		n 233″·7279
i	22	32	33·2		T 1892 April 14·5645
ϕ	40	19	8·1		Period 15·1809 years.

The three positions are exactly reproduced.

3 *Verulam Buildings, Gray's Inn, W.C.:*
1892 *December* 9.

Observations of Holmes' Comet (f 1892) made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East, or Sheepshanks Equatoreal, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination (also occasionally over a third wire bisecting the angle between the other two). Magnifying power, 55.

The observations are corrected for refraction, but not for parallax.

Greenwich Mean Solar Time.				Observer.	♂ − ✱ R.A.	Log factor of Parallax.	Corr. for Refraction.	♂ − N.P.D.	Log factor of Parallax.	Corr. for Refraction.	No. of Comps.	Apparent R.A.	Apparent N.P.D.	Comp. ✱
1892	d	h m	s		m s		s	′ ″		″		h m s	° ′ ″	
Nov.	12	8 27	17	A. C.	+0 19·35	8·9679	0·00	+ 8 40·5	0·3237	+0·2	4	0 44 28·55	51 59 14·3	*a*
	12	8 29	52	,,	−2 27·20	8·9544	0·00	− 2 59·1	0·3218	−0·1	2	0 44 32·26	51 58 51·3	*b*
	12	8 29	49	C. D.	−2 29·28	8·9593	0·00	− 3 18·3	0·3211	−0·1	2	0 44 30·18	51 58 32·1	*b*
	12	8 35	58	,,	+0 19·21	8·8533	0·00	+ 8 17·1	0·3193	+0·2	4	0 44 28·41	51 58 50·9	*a*
	14	6 21	19	B.	−3 13·92	9·4887	0·00	+ 7 22·6	0·4631	0·0	2	0 43 45·53	52 9 12·8	*b*
	14	6 37	45	,,	+0 0·21	9·4497	+0·01	−12 23·0	0·4390	0·0	3	0 43 41·41	52 10 13·7	*c*
	14	6 43	58	C. D.	−3 12·54	9·4316	0·00	+ 8 32·3	0·4307	+0·1	2	0 43 46·91	52 10 22·6	*b*
	14	7 3	14	,,	+0 2·81	9·3669	0·00	−12 0·5	0·4055	0·0	6	0 43 44·00	52 10 36·2	*c*
	14	8 2	6	,,	−0 21·17	9·1089	0·00	+20 8·7	0·3405	+0·1	1	0 43 48·01	52 10 42·1	*a*
	14	8 2	6	,,	−0 25·67	9·1089	0·00	+18 19·8	0·3405	0·0	1	0 43 48·14	52 10 38·8	*d*
	14	7 27	0	L.	+0 1·02	9·2904	0·00	−11 54·3	0·3749	0·0	2	0 43 42·21	52 10 42·4	*c*

Greenwich Mean Solar Time.					Observer.	✐ − ✱ R.A.	Log factor of Parallax.	Corr. for Refraction.	✐ − ✱ N.P.D.	Log factor of Parallax.	Corr. for Refraction.	No. of Comps.	Apparent R.A.	Apparent N.P.D.	Comp. ✱
1892	d	h	m	s		m s		s	′ ″		″		h m s	° ′ ″	
Nov.	14	7	58	12	L.	−0 23·00	9·1345	0·00	+20 5·7	0·3440	+0·1	1	0 43 46·18	52 10 39·1	*a*
	17	8	50	30	A. C.	−0 49·54	7·7559	0·00	+ 7 1·0	0·3238	+0·1	5	0 42 51·62	52 29 37·4	*c*
	18	6	5	48	C. D.	−2 41·41	9·4829	0·00	+ 3 9·5	0·4684	0·0	2	0 42 38 27	52 35 22·2	*e*
	18	6	19	54	,,	−1 2·20	9·4455	0·00	+12 49·7	0 4496	+0·1	3	0 42 38 95	52 35 26·0	*c*
	18	7	25	21	D. E.	−2 48·72	9·2167	0·00	+ 4 12·5	0·3697	0·0	4	0 42 30 96	52 36 25·2	*e*
	18	10	8	2	L.	−1 9·43	9·1921	0·00	+13 45·3	0·3645	+0·1	2	0 42 31 72	52 36 21·6	*c*
	20	6	20	17	A. C.	+0 28 97	9 4258	0·00	− 8 54·9	0·4417	−0·1	5	0 42 19 49	52 48 9·8	*f*
	20	6	26	29	,,	+1 39·18	9·4094	0·00	− 0 59·6	0·4335	0·0	3	...	...	*g*
	21	7	10	38	L.	+0 18 98	9·2274	0 00	− 1 54·9	0·3810	0 0	4	0 42 9·49	52 55 9·6	*f*
	21	7	56	23	,,	−0 36·10	8·9088	0·00	+ 8 13·4	0·3464	+0·1	2	...	...	*h*
	21	8	9	47	D. E.	+0 18·69	8·7328	0·00	− 0 18·1	0·3405	0·0	2	0 42 9·20	52 56 46·6	*f*
	26	9	2	3	A. C.	+0 43·33	8·9476	0 00	+ 8 51·1	0·3637	−0·2	3	0 42 9·53	53 27 15·5	*i*
	26	9	15	49	,,	+1 8·64	9 0669	0 00	− 5 55·7	0·3725	+0·2	2	0 42 9·83	53 27 28·5	*k*
	26	9	16	47	,,	−0 45·20	9·0741	0·00	− 1 51·5	0 3730	+0·1	1	...	...	*l*

Note.

Throughout this period the comet was very ill-defined, with little, if any, trace of a nucleus.

The initials L., A. C., B., C. D., D. E., are those of Mr. Lewis, Mr. Crommelin, Mr. Bryant, Mr. Davidson, and Mr. Edney respectively.

Comparison Stars.

	Star's Name.	R.A. 1892·0. h m s	N.P.D. 1892·0. ° ′ ″	Authority.
a	W. B. (2), 0, 1083	0 44 6·22	51 50 59·8	Weisse's Bessel.
b	Lalande, 1443	0 46 56·48	52 2 16·6	Paris Catalogue.
c	Lalande, 1323	0 43 38·25	52 23 3·1	" "
d	W. B. (2), 0, 1087	0 44 10·85	51 52 45·5	Weisse's Bessel.
e	Lalande, 1384	0 45 16·76	52 32 39·6	Paris Catalogue.
f	W. B. (2), 0, 1029	0 41 47·65	52 57 31·6	Weisse's Bessel.
g	B. D. + 36°, 122	0 40 38·2	52 49·5	Bonn Observations.
h	B. D. + 37°, 141	0 42 40 7	52 47·2	" "
i	W. B. (2), 0, 1021	0 41 23·39	53 18 52·2	Weisse's Bessel.
k	W. B. (2), 0, 1013	0 40 58·37	53 33 51·6	" "
l	B. D. + 36°, 128	0 42 49·7	53 29·2	Bonn Observations.

Royal Observatory, Greenwich:
1892 *December* 6.

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*Errata in "Monthly Notices," Vol. LII., No. 7, page 515, Comparison of Swift with * f.*

May 5 $13^h\ 43^m\ 42^s$ ☄ − * R.A., for 18″·13 read 78″·13

Apparent R.A. of ☄, insert $22^h\ 45^m\ 42^s·49$.

Apparent N.P.D. of ☄, insert 66° 14′ 8″·8.

Page 516. Star *f* is not anonymous, but is W. B. (2), XXII., 994;
Mean R.A. 1892·0, $22^h\ 44^m\ 24^s·87$, N.P.D. 66° 13′ 19″·6, Authority: Lalande and Weisse's Bessel.

Observations of Winnecke's Periodical Comet at Windsor, New South Wales. By John Tebbutt.

Winnecke's Comet was found with the help of Dr. von Haerdtl's ephemeris on June 12, but as it could be well seen from the northern hemisphere and was unfavourably placed here for observation, no observations were then attempted. The comet was picked up on July 17, after having passed conjunction with the Sun, and was observed on all possible occasions, when the weather and the Moon's absence permitted, till September 27. All the positions sent herewith were determined with a square bar-micrometer, the $4\frac{1}{2}$-inch equatoreal being employed on July 17 and the 8-inch instrument on all the other dates. On looking for the comet on September 27 it could not be seen as a separate object, but a small star of the tenth magnitude was found fringed with a faint nebulous haze. As the position of this object agreed closely with that derived from an extension of Dr. Haerdtl's ephemeris in *Ast. Nach.*, No. 3083, I made four comparisons of it with comparison star No. 29. Clouds prevented further observations, so that the separation of the comet from the small star was not seen.

I trust the series of positions now sent will turn out as useful as those published for the last return in the forty-seventh volume of the *Monthly Notices*. I may add that a careful search was made here for Comet Tempel 1867 II. on June 19 between $17^h\ 30^m$ and $18^h\ 50^m$ of R.A. and 25° and 32° of south declination, but although the sky was brilliantly clear and the Moon absent, no trace of the comet could be found.

Private Observatory, The Peninsula, Windsor, N. S. Wales:
1892 *October* 27.

Observations of Winnecke's Comet.

1892.	Windsor Mean Time.	Comet−Star. Δ R.A.	Comet−Star. Δ N.P.D.	Comps.	Comet's App. R.A.	Log. $p\Delta$.	Comet's App. N.P.D.	Log. $p\Delta$.	Reduction to App. Place.		Star.
	h m s	m s	′ ″		h m s	−	° ′ ″	+	s	″	
July 17	17 48 57	+0 55·54	− 2 32·3	10	5 15 18 04	9·6095	94 56 36·9	0·6524	−0·11	−12·1	1
19	17 19 27	+1 58·15	+ 1 55·0	10	...	9·6200	...	0·6264	−0·02	−13·6	2
20	17 41 36	−0 37·89	+ 2 23·5	10	...	9·5739	...	0·5972	+0·01	−14·3	3
20	17 48 33	+2 42·36	+ 0 46·7	8	...	9·5619	...	0·5939	+0·02	−14·4	4
21	17 30 57	−3 17·05	+ 5 7·8	14	...	9·5760	...	0·5814	+0·04	−14·9	5
22	17 15 33	+2 53·70	− 0 36·2	12	4 39 34·06	9·5869	102 40 11·1	0·5698	+0·12	−15·9	6
23	17 48 41	+7 11·65	+ 1 51·9	5	4 33 38·50	9·5058	103 54 5·5	0·5257	+0·19	−16·7	7
24	17 26 26	−3 38·77	− 8 53·0	8	4 28 18·80	9·5366	104 59 35·5	0·5182	+0·17	−17·0	8
27	17 35 16	+0 6·79	− 7 31·2	11	4 14 2·36	9·4580	107 50 23·0	0·4409	+0·34	−18·9	9
28	16 31 47	−1 2·85	+ 0 44·9	10	...	9·5842	...	0·4816	+0·38	−19·3	10
	16 31 47	−4 55·63	− 9 28·5	10	...	9·5842	...	0·4816	+0·35	−19·3	11
29	16 15 24	+2 1·60	− 2 38·6	10	4 6 10·03	9·6003	109 22 4·6	0·4798	+0·44	−19·9	12
29	16 15 24	+0 58·57	+ 5 17·9	10	4 6 10·19	9·6003	109 22 6·5	0·4798	+0·44	−19·9	13
29	16 57 17	+0 57·45	−10 31·4	7	4 6 3·38	9·5190	109 23 21·3	0·4312	+0·44	−20·0	14
Aug. 2	16 9 18	+1 43·33	+ 2 35·1	9	3 52 22·87	9·5661	111 55 32·6	0·4038	+0·64	−21·7	15
2	16 9 18	+1 26·47	+ 1 7·6	9	3 52 23·05	9·5661	111 55 31·1	0·4038	+0·64	−21·7	16
3	15 54 24	+1 12·59	− 7 49·1	10	3 49 21·73	9·5826	112 27 48·8	0·4075	+0·68	−22·1	17

1892.	Windsor Mean Time.	Comet − Star. Δ R.A.	Δ N.P.D.	Comps.	Comet's App. R.A.	Log. $p\Delta$.	Comet's App. N.P.D.	Log. $p\Delta$.	Reduction to App. Place.		Star.
	h m s	m s	′ ″		h m s	−	° ′ ″	+	s	″	
Aug. 15	13 50 8	−2 27·04	− 8 24·0	12	3 19 31·69	9·6704	117 12 59·9	0·4042	+1·24	−25·5	18
23	13 57 48	+7 9·54	+ 0 13·6	8	3 1 41·85	9·5899	119 19 57·8	0·2121	+1·72	−26·7	19
23	13 57 48	−5 48·80	− 4 18·9	8	3 1 41·78	9·5899	119 20 2·4	0·2121	+1·61	−26·8	20
25	13 34 22	−2 1·44	+ 6 23·0	10	2 57 12·09	9·6128	119 45 42·3	0·2297	+1·74	−26·9	21
26	13 44 17	−1 18·35	− 9 51·3	10	2 54 53·74	9·5823	119 57 52·2	0·1737	+1·80	−27·0	22
27	13 56 2	+3 54·57	− 6 30·5	10	2 52 35·15	9·5424	120 9 32·7	0·1080	+1·89	−27·0	23
27	13 56 2	+2 31·18	− 6 54·1	10	2 52 35·26	9·5424	120 9 32·5	0·1080	+1·88	−27·0	24
Sept. 16	10 0 45	+0 43·27	+ 9 52·2	10	...	9·7207	...	0·3964	+2·76	−25·4	25
16	10 0 45	−2 19·91	+ 0 59·7	10	...	9·7207	...	0·3964	+2·74	−25·5	26
17	10 36 5	−1 45·31	+ 8 43·6	10	...	9·6744	...	0·2751	+2·78	−25·3	25
17	10 36 5	−4 48·47	− 0 8·3	10	...	9·6744	...	0·2751	+2·76	−25·4	26
18	11 10 3	+2 7·38	− 1 44·2	5	...	9·6087	...	0·1327	+2·84	−24·9	27
18	11 10 3	−4 13·13	+ 6 54·6	5	...	9·6087	...	0·1327	+2·80	−25·2	25
18	11 10 3	−7 16·36	− 1 58·7	5	...	9·6087	...	0·1327	+2·78	−25·3	26
20	11 49 45	+2 34·29	+10 12·9	10	1 54 55·45	9·4790	121 46 26·2	9·9195	+2·91	−24·5	28
22	10 33 58	−1 58·05	+ 2 28·5	15	1 50 23·15	9·6279	121 38 42·1	0·1814	+2·95	−24·2	28
26	11 3 48	+2 15·77	− 0 0·2	10	1 41 20·79	9·5030	121 15 46·1	9·9897	+3·07	−23·0	29
27	11 34 5	+0 2·09	− 7 31·4	4	1 39 7·13	9·3766	121 8 15·0	9·8444	+3·09	−22·9	29

Mean Places of the Comparison Stars for 1892·0.

Star.	B.A. h m s	N.P.D. ° ′ ″	Authorities.
1	5 14 22·61	94 59 21·3	Lalande, 9981–2.
2	4 57 34	98 22	Equatoreal.
3	4 52 59	99 55	Equatoreal.
4	4 49 37	99 57	Equatoreal.
5	4 49 0	101 18	Equatoreal.
6	4 36 40·24	102 41 3·2	Lalande, 8880; Schjellerup, 1508–9; $Armagh_2$, 580.
7	4 26 26·66	103 52 30·3	Lalande, 8575; Schjellerup, 1449.
8	4 31 57·40	105 8 45·5	Lalande, 8745–6; Arg.–Oeltzen, 3220–1.
9	4 13 55·23	107 58 13·1	Lalande, 8119.
10	4 11 8	108 36	Equatoreal.
11	4 15 1	108 47	Equatoreal.
12	4 4 7·99	109 25 3·1	Arg.–Oeltzen, 2842; Cincinnati Zone, 579.
13	4 5 11·18	109 17 8·5	Lalande, 7815; Cincinnati Zone, 584; $Armagh_2$, 516.
14	4 5 5·49	109 34 12·7	Arg.–Oeltzen, 2861; Cincinnati Zone, 583.
15	3 50 38·90	111 53 19·2	Lalande, 7298; Cincinnati Zone, 542.
16	3 50 55·94	111 54 45·2	Lalande, 7311; Cincinnati Zone, 543.
17	3 48 8·46	112 36 0·0	Lalande, 7217; Arg.–Oeltzen, 2613.
18	3 21 57·49	117 21 49·4	Arg.–Oeltzen, 2279; Cordoba Zone, 46·103.
19	2 54 30·59	119 20 10·9	Arg.–Oeltzen, 1951; Brussels, 1165; Cordoba Zone, 73·116; Stone, 1233.
20	3 7 28·97	119 24 48·1	$Yarnall_2$, 1375; Brussels, 1228; Cordoba Zone, 73·136. Greenwich Cat., 1880·484; Stone, 1317
21	2 59 11·79	119 39 46·2	Arg.–Oeltzen, 2006; Cordoba Zone, 73·123.
22	2 56 10·29	120 8 10·5	Arg.–Oeltzen, 1970; Cordoba Zone, 73·120.
23	2 48 38·69	120 16 30·2	Arg.–Oeltzen, 1881; Cordoba Zone, 73·109.
24	2 50 2·20	120 16 53·6	Arg.–Oeltzen, 1899–1900; Cordoba Zone, 73·110.
25	2 4 0	121 45	Equatoreal.
26	2 7 4	121 54	Equatoreal.
27	1 57 40	121 55	Equatoreal.
28	1 52 18·25	121 36 37·8	Cordoba Zone, 107·43; Stone, 770.
29	1 39 1·95	121 16 9·3	Cordoba Zone, 107·20.

Galactic Longitudes and Latitudes of the brighter Stars in a Zone of the Heavens containing the Milky Way. By A. Marth.

In a paper communicated, twenty years ago, to the Royal Astronomical Society by Mr. Lassell, and published in vol. xxxiii. of the *Monthly Notices* (pp. 1–14 and 517–527), with a supplement published in vol. xxxiv. (pp. 77–82), I supplied the galactic co-ordinates of the leading stars within or near the Milky Way, so that they might serve as a correct groundwork for representations of the Galaxy, for which an appeal was made to competent draughtsmen. At that time the only accessible modern delineation of the Milky Way derived directly from the sky was that of the southern portion from Antinous to Monoceros, found on plate xiii. of Sir John Herschel's Results of Astronomical Observations made at the Cape of Good Hope. As explained in article (341) of the volume, Herschel had made his original drawings on a larger scale on blank paper on which he had pricked off the stars from Bode's charts. Adopting for his general map the projection, in which the galactic circle or the medial line of the entire Galaxy is extended into a straight line, he had then laid down "(from a good celestial globe, by Bardin, for 1800) the chief stars as a skeleton—inserting others from the maps by the aid of proportional compasses," and had worked over it an accurate resemblance of the forms and, as near as possible, of the intensities of the several parts of the Milky Way as represented in the original drawings. Whatever device may have been used in transferring the positions of the chief stars from the globe to the sheet of paper, the introduction of some sensible inaccuracies in fixing the positions in that way could not well be avoided, and it was with the view of sparing intending draughtsmen all such preliminary trouble, and of insuring the correct positions of the stars, that I prepared the former list of co-ordinates, in the hope that competent observers would take advantage of the means thus provided.

A few years later I was informed by Mr. Trouvelot, then at Cambridge, Mass., that he had adopted the data of the list as the foundation of a pastel drawing of the Galaxy, which was being exhibited at the Philadelphia Exhibition of 1876, and that it was under consideration how to get it published. As I had not heard since what had become of the publication, I wrote last May to Mr. Trouvelot, now at Meudon, to inquire, and he was good enough not only to give me the desired information, but also to send me, with some smaller photographs, a print (white on black) of the one-half of his drawing which has been published by Charles Scribner's Sons, of New York, in their series of astronomical drawings. This print is now in the library of the Royal Astronomical Society, to which, by leave and in the name

of Mr. Trouvelot, I have transferred it. An extract from his letter will best explain several peculiarities of the print:—

"The list of co-ordinates of stars which you published served as basis for the drawing. But in order to make a picture, the vacant spaces were filled in with stars borrowed from Dien's *Star Atlas*; but this latter task was made very rapidly, and without any pretensions to absolute accuracy.

"In the United States, where the sky is of extraordinary clearness, the Galaxy sometimes appears all flaky and sparkling with stars, which appear as minute clusters, and at times seem to blaze forth with 'star-dust.'

"The critique I will make concerning my drawing is that the dark channels dividing the luminous masses are a little too dark, and that it would more nearly represent the truth if these dark gaps were slightly illuminated, so that the contrast between the bright and the dark portions should become less marked."

Elaborate representations of the regions of the Galaxy south of 12°·5 of northern declination became accessible in 1877 by the publication of the Atlas of the *Uranometria Argentina*, one of the results of the great work accomplished by Dr. Gould and his assistants at Cordoba. "The position and ramification of the Milky Way were elaborately delineated by Mr. Thome, and minutely scrutinised by direct comparison with the heavens during the preparation of each map" (*Uranometria Argentina*, p. 9). The drawings "exhibit many details of outline and contrasts of brilliancy, which are not clearly perceptible except upon the clearest and darkest nights" (p. 344). "The mode of representation which has been adopted was required by the photographic process of transfer, which is inadequate to an equal and exact reproduction of shading or tints in the original, and made it necessary to employ in its preparation only black ink of uniform colour" (p. 345). These explanations refer to the detailed representations of the portions of the Milky Way given on ten of the maps, from which any desired information has to be gathered. For the comprehensive sketch on the index map merely fulfils its purpose to serve as an index sketch, and fails in resembling the real aspect of the Galaxy, since in the adopted isographic projection the distances between successive parallels of declination decrease in the ratio of $1 : \cos \frac{1}{2}\varpi$ (if ϖ denotes the polar distance), while the corresponding distances in right ascension increase in the ratio of $1 : \sec \frac{1}{2}\varpi$, the ratio of areas not being impaired.

In the stereographic projection of not less than 100 degrees radius, which Dr. Boeddicker has adopted for his elaborate Map of the Milky Way as seen in our northern latitudes, the great variation of scale is a most serious drawback. The scale increases indeed equally for both co-ordinates, but at the rate of $1 : \sec^2 \frac{1}{2}\varpi$ for arcs, and therefore of $1 : \sec^4 \frac{1}{2}\varpi$ for areas, so that at the polar distances—

0°	30°	40°	50°	60°	70°	80°	90°	100°

the ratios of equivalent arcs are

1	1·07	1·13	1·22	1·33	1·49	1·70	2·00	2·42

and of equivalent areas—

1	1·15	1·28	1·48	1·78	2·22	2·90	4·00	5 86

The necessity of making due allowance for this distortion in all studies of the drawing renders the correct interpretation of its many delicate features, and the proper comparison of the evidence, which is to be found in the details, needlessly troublesome and difficult. Fair justice does not seem to have been done to the high value of the original sectional drawings by their being unsuitably combined.

A comprehensive drawing, representing the whole girdle of the Galaxy, on a uniform scale and without appreciable distortion, and allowing direct comparison of all its parts, such as I had in view when I prepared my old paper, is not yet in existence. It is, however, not for the purpose of making another appeal to the comparatively few observers, who might give their help as competent draughtsmen in the production of such a drawing, that I have prepared the greatly enlarged galactic catalogue contained in the present paper. The chief reason why I have not grudged the time which its preparation has cost, is the consideration that the regular watching and controlling of the richest regions of the heavens for the timely discovery of the brighter variable, and especially temporary, stars may thereby be rendered comparatively easy to all observers who are willing to take part in the watching. But for the purpose it is important, and almost essential, that they should prepare their star-maps with their own hands. Let them select any special region in the zone of the Galaxy, and lay down the galactic places of the stars within the region on properly prepared paper (be it millimetre paper or paper covered with subdivisions of inches). The mere insertion of the places, and their being marked by suitable discs according to the various magnitudes, will already be of great help in procuring acquaintance with the selected region. The comparisons with the heavens may then be made in the usual way by letting light shine on the map. But in order to save the eyes from much of the usual strain occasioned thereby, let the map be darkened on the back, or mounted on dark paper, and let the star-places be pricked by means of pricking needles of suitable diameters, the needles being mounted on pieces of cork, so that they may be heated to make clean holes, if some better contrivance is not found. The comparisons with the heavens may then be made in the dark, by letting some concealed light be seen through the holes, and they will be found far more expeditious and satisfactory than when made in the usual way.

As regards the question of scale, the suggestion of an inch for five degrees, or a centimetre for two degrees, still seems to

me, for unaided vision, the most practical, except perhaps if paper is used on which the inch is subdivided into twenty parts in groups of five, when an inch for four degrees will be more convenient. As regards the star discs, proper experiments should be made to decide upon the most suitable size. If the discs are to be proportional to the amount of light, the diameter δ of a star of magnitude m should be such that $\log \delta = 0{\cdot}2\ (m_0 - m)$, if 1 is the diameter of a star of magnitude m_0. But the condition renders the discs of bright stars unnaturally large, so that some compromise will be preferable.

The following catalogue supplies the galactic longitudes and latitudes of all the stars down to the magnitude $6^m{\cdot}0$ of the *Harvard Photometry* (H. P.), or $6^m{\cdot}2$ of the *Uranometria Argentina* (U. A.), which are within twenty degrees of the central line of the Galaxy, for which I have retained the assumptions of my former paper, which differ little from Argelander's, and according to which the pole of the Galaxy is in right ascension $12^h\ 40^m$, and declination $+30°$ for 1880·0, so that the inclination of the central line to the equator is 60°, and the ascending node, from which the galactic longitudes are reckoned, in right ascension $18^h\ 40^m$.

The central line of the Galaxy, according to Gould's later determination, makes an angle of 2°·70 with the assumed one, but as I could not afford to repeat my old computations, it will be sufficient if I supply at the end of the catalogue the data for inserting on the map Gould's line, equator, ecliptic, &c.

Besides the stars mentioned, the catalogue contains a number of lesser stars, which have been inserted for various reasons, also a considerable number of stars outside the twenty degrees limits. The magnitudes stated are those of the Harvard Photometry and of the *Uranometria Argentina*, except in the case of variable stars, when the limits of variability, taken from the latest lists, are given. The sign *d* of duplicity is not added, if the comes is too faint to appreciably affect the magnitude. If a star is placed in different constellations, both constellations are mentioned. The last columns give the right ascension α and declination δ for 1880·0.

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.			Star.		α 1880. h	m	s	δ 1880. °	′
°	°	m	m									
0·01	−20·91	5·9	6·1			Aquilæ		19	53	16	−10	16·3
0·98	−18·96	5·3	5·7	*d*	57	„		19	48	8	− 8	32·3
1·53	+ 1·23	5·1	5·5		4	„		18	38	47	+ 1	56·3
2·16	−13·58	5·6	5·8		42	„		19	31	25	− 4	54·9
2·56	+ 3·85	5·5	5·8		60	Serpentis		18	23	26	− 2	3·7
2·57	+21·46	2·2	....		55	*α* Ophiuchi		17	29	22	+12	38·9
2·86	+12·63	4·8	5·0		71	„		18	1	34	+ 8	43·2
2·93	−11·13	5·2	5·6		56	*e* Aquilæ		19	24	23	− 3	2·3
2·97	+ 9·35	5·7	5·8			Ophiuchi		18	13	21	+ 7	12·7
3·10	+ 6·92	5·7	6·0			„	Serp.	18	22	7	+ 6	7·3
3·31	+ 7·26	cum.			VIII 72	„	„ 8m·6	18	21	45	+ 6	28·7
3·35	− 8·00	5·6	5·9		27	*d* Aquilæ		19	14	24	− 1	6·8
3·47	− 1·24	5·7	6·0		64	Serpentis		18	51	15	+ 2	22·7
3·61	− 2·95	5·8	6·3			Aquilæ		18	57	28	+ 1	38·8
3·62	+13·01	3·8	3·6		72	Ophiuchi		18	1	40	+ 9	32·9
4·13	− 8·07	6·0	6·3			Aquilæ		19	16	11	− 0	28·7
4·44	+ 8·31	5·8	5·9			Ophiuchi,	Serp.	18	19	52	+ 7	57·9
4·57	+ 5·26	5·3	5·8			„	„	18	30	49	+ 6	34·7
4·61	+ 2·78	5·7	5·9			Serpentis		18	39	34	+ 5	22·6
4·79	+ 0·19	4·7	4·5		63	*θ* „		18	50	15	+ 4	2·9
...	...	5·1	4·7					18	50	17	+ 4	2·8
4·83	− 6·58	5·4	5·7		23	Aquilæ		19	12	26	+ 0	52·1
5·03	−11·70	4·3	4·6		41	*ι* „		19	30	31	− 1	33·1
5·18	− 8·68	4·8	5·4		32	*ν* „		19	20	23	+ 0	6·0
5·28	− 4·93	5·2	5·7		21	„		19	7	40	+ 2	5·4
5·42	+20·25	6·1	...			Ophiuchi		17	38	50	+14	27·8
5·51	−16·20	5·7	5·9			Aquilæ		19	47	2	− 3	25·4
6·13	−12·24	5·5	5·9		45	„		19	34	32	− 0	53·9
6·63	+21·42	5·7	...			Ophiuchi		17	36	36	+16	0·5
6·71	+ 6·48	5·5	5·7			„	Serp.	18	30	44	+ 9	1·7
6·80	+ 1·16	5·7	5·8		62	Serpentis		18	49	36	+ 6	28·0
6·90	− 8·42	5·7	6·1		35	*c* Aquilæ		19	22	57	+ 1	42·4
7·48	− 7·07	3·5	3·4		30	*δ* „		19	19	27	+ 2	52·6
7·65	+10·87	5·9	6·1			Ophiuchi		18	17	0	+11	58·3
7·85	− 4·27	5·4	6·1		22	Aquilæ		19	10	35	+ 4	37·5
7·99	− 2·03	5·3	5·7		19	„		19	3	7	+ 5	53·1
8·74	−14·82	5·6	5·9		58	„		19	48	36	− 0	2·3
8·86	−14·09	var.	3·5−4·7		55	*η* „		19	46	22	+ 0	41·9

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h	m	s	δ 1880. °	′
°	°	m	m								
8·90	+21·07	5·7	...			Herculis	17	41	50	+17	44·5
9·14	−17·39	5·9	6·1	62		Aquilæ	19	58	12	− 1	2·6
9·42	+17·88	4·5	5·3	93		Herculis	17	54	43	+16	45·5
9·55	− 0·39	var.	6·4−11		R	Aquilæ	19	0	35	+ 8	4·0
9·96	−18·93	3·4	3·0	65	θ	,,	20	5	7	− 1	10·6
10·05	−19·44	5·7	5·8	66		,,	20	7	2	− 1	22·1
10·59	−23·93	5·2	5·3	69		,,	20	23	23	− 3	17·0
11·21	− 8·86	5·0	5·7	44	σ	,,	19	33	16	+ 5	7·5
11·91	−25·26	5·3	5·1	70		,,	20	30	29	− 2	57·9
12·08	+ 0·88	5·1	5·6	18		,,	19	1	20	+10	53·2
12·27	− 6·75	4·7	5·3	38	μ	,,	19	28	14	+ 7	7·5
12·70	+14·63	6·1	...			Herculis	18	12	51	+18	5·2
12·81	+ 5·48	6·0	6·6			Aquilæ	18	46	32	+13	49·4
12·93	+13·49	5·5	...			Herculis	18	17	31	+17	46·0
13·04	+11·33	5·7	...			,,	18	25	44	+16	50·8
13·35	+ 3·82	5·2	5·8	11		Aquilæ	18	53	34	+13	27·8
13·48	+17·43	5·2	...	101		Herculis	18	3	42	+20	1·7
13·49	−24·85	4·4	4·5	71		Aquilæ	20	32	8	− 1	31·4
13·53	−20·79	6·1	6·4			,,	20	18	31	+ 0	40·9
13·55	−19·14	5·1	...	96		Herculis	17	57	15	+20	50·1
13·86	− 1·16	5·1	5·7	25	α	Aquilæ	19	12	11	+11	22·8
13·97	− 9·09	5·8	6·2	49	υ	,,	19	39	50	+ 7	19·4
14·19	+19·65	4·6	... *d*	95		Herculis	17	56	25	+21	35·8
14·20	+17·78	4·5	...	102		,,	18	3	38	+20	47·8
14·21	−11·75	4·0	3·9	60	β	Aquilæ	19	49	25	+ 6	6·5
14·31	+ 2·60	3·1	...	17	ζ	,,	18	59	54	+13	41·2
14·46	+21·20	5·8	...			Herculis	17	50	48	+22	29·0
14·65	+11·04	5·6	...			,,	18	29	56	+18	6·5
14·67	+ 4·40	4·1	...	13	ε	Aquilæ	18	54	11	+14	54·4
14·76	−11·35	5·4	5·9	28	A	,,	19	14	3	+12	9·2
15·02	− 2·49	5·3	5·6	31	*b*	,,	19	19	15	+11	41·3
15·14	−24·22	5·4	5·6	1		Aquarii	20	33	16	+ 0	3·9
15·26	+18·96	5·4	...	98		Herculis	18	0	59	+22	12·5
15·70	+16·09	3·9	...	109		,,	18	18	35	+21	43·0
15·71	− 9·50	1·0	1·1	53	α	Aquilæ	19	44	56	+ 8	33·1
15·84	−10·44	4·9	5·3	59	ξ	,,	19	48	26	+ 8	9·1
15·95	+ 8·55	4·5	...	111		Herculis	18	41	43	+18	2·9
[15·98	− 5·33	6·0	6·5			Aquilæ	19	31	12	+11	0·4

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ 1880. ° ′
16°15	−13°15	5·6	5·9	63	τ Aquilæ	19 58 17	+ 6 56·4
16·15	− 2·24	5·8	6·2		,,	19 20 49	+ 12 47·0
16·24	+ 0·62	5·4	6·2		,,	19 10 57	+ 14 20·0
16·50	+ 15·86	4·8	...	106	Herculis	18 15 13	+ 21 54·7
16·53	+ 5·81	5·2	5·7		Aquilæ	18 52 54	+ 17 12·0
16·57	+ 1·12	5·5	6·0		,,	19 9 52	+ 14 52·5
16·62	− 7·64	2·8	2·7	50	γ ,,	19 40 33	+ 10 19·3
16·83	− 11·80	6·1	6·2		,,	19 55 11	+ 8 13·7
16·91	+ 23·93	5·4	...	87	Herculis	17 43 57	+ 25 39·8
16·94	+ 6·62	5·8	...		,,	18 50 48	+ 17 57·4
17·09	− 8·73	5·2	5·7	54	*o* Aquilæ	19 45 17	+ 10 7·0
17·14	− 18·18	5·4	5·8	23	Her. ,,	20 17 14	+ 4 57·6
17·19	− 6·23	5·4	5·8	47	χ ,,	19 36 55	+ 11 32·7
17·20	+ 8·71	5·9	...		Herculis	18 43 39	+ 19 11·7
17·23	+ 3·56	5·9	...		Aquilæ	19 2 34	+ 16 40·5
17·88	− 2·04	5·7	5·9		,,	19 23 51	+ 14 21·0
17·92	+ 16·05	5·7	...		Herculis	18 17 8	+ 23 13·5
17·94	+ 9·94	4·2	...	110	,,	18 40 30	+ 20 26·0
17·96	+ 22·72	5·6	...	89	,,	17 50 35	+ 26 4·2
17·98	− 7·51	5·7	6·6	52	π Aquilæ	19 43 3	+ 11 31·1
18·49	+ 15·64	6·0	...		Herculis	18 27 47	+ 23 31·7
18·64	− 9·28	5·4	5·7	61	φ Aquilæ	19 50 33	+ 11 6·4
18·70	− 4·88	5·9	6·1		,,	19 35 32	+ 13 32·3
18·72	+ 17·16	5·5	...	105	Herculis	18 14 14	+ 24 23·8
18·87	+ 25·20	3·5	...	86	μ ,,	17 41 46	+ 27 47·5
19·19	+ 20·18	5·2	... *d*	100	,,	18 2 59	+ 26 4·9
19·24	+ 14·76	5·7	...		,,	18 24 37	+ 23 47·2
19·27	+ 0·19	6·0	...	2	Sagittæ	19 18 59	+ 16 42·3
19·45	+ 8·99	5·5	...	112	Herculis	18 47 9	+ 21 16·9
19·61	+ 13·43	5·8	...		,,	18 30 31	+ 23 30·6
19·74	− 12·21	6·0	6·4		Aquilæ	20 2 55	+ 10 22·6
20·47	− 2·70	5·6	...	4	ε Sagittæ	19 31 51	+ 16 11·7
20·81	+ 9·07	4·6	...	113	Herculis	18 49 41	+ 22 29·7
20·83	+ 24·97	5·7	...		,,	17 45 44	+ 29 21·3
20·89	+ 10·78	6·0	...		,,	18 43 16	+ 23 22·9
21·39	+ 23·45	3·9	...	92	ξ ,,	17 53 6	+ 29 15·7
21·78	+ 21·28	4·0	...	113	*o* ,,	18 2 52	+ 28 44·8
21·81	− 2·93	4·4	...	6	β Sagittæ	19 35 40	+ 17 11·9

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h	α 1880. m	α 1880. s	δ 1880. °	δ 1880. ′	δ 1880. ″
°	°	m	m									
21·86	+ 1·43	5·2	...	4		Vulpeculæ	19	20	13	+ 19	33	8
21·86	+ 4·91	5·8	...			„	19	7	28	+ 21	21	2
21·89	+ 4·21	5·8	...	1		Sagittæ	19	10	7	+ 21	1	4
22·13	− 2·46	4·3	...	5	α	„	19	34	44	+ 17	44	3
22·14	+ 4·10	4·7	...	1		Vulpeculæ	19	11	4	+ 21	10	8
22·21	+ 1·43	5·4	...	5		„	19	20	59	+ 19	51	6
22·42	+ 23·64	4·6	...	94	ν	Herculis	17	53	55	+ 30	12	0
22·95	− 0·42	5·0	...	9		Vulpeculæ	19	29	19	+ 19	30	7
22·98	− 16·50	5·9	6·1	1		Delphini	20	24	33	+ 10	29	7
23·03	− 6·40	var.	5·6 − 6·4	10	S	Sagittæ	19	50	34	+ 16	19	1
23·13	+ 18·61	5·0	...	107	ι	Herculis	18	16	20	+ 28	48	8
23·39	− 6·66	5·3	...	11		Sagittæ	19	52	19	+ 16	28	0
23·50	− 3·48	3·7	...	7	δ	„	19	42	2	+ 18	14	3
23·52	− 8·23	5·2	6·0	14		„	19	58	1	+ 15	41	7
23·52	+ 22·06	5·4	...	99	b	Herculis	18	2	28	+ 30	32	7
23·52	+ 12·66	4·9	...			Lyræ	18	41	14	+ 26	32	1
23·55	+ 7·43	5·6	...			Vulpeculæ	19	1	38	+ 24	3	9
23·61	− 18·73	5·1	5·6	7	κ	Delphini	20	33	18	+ 9	39	8
23·73	+ 4·62	5·6	...	2		Vulpeculæ	19	12	39	+ 22	48	6
23·76	− 16·85	4·1	4·2	2	ε	Delphini	20	27	29	+ 10	53	8
24·08	+ 19·03	5·6	...	108		Herculis	18	16	20	+ 29	48	2
24·22	− 3·63	5·0	...	8	ζ	Sagittæ	19	43	39	+ 18	50	5
24·27	+ 18·36	5·8	...			Lyræ	18	21	21	+ 29	45	6
24·30	− 6·72	5·5	...	13		Sagittæ	19	54	38	+ 17	11	4
24·30	− 10·84	5·1	5·4	67	ρ	Aquilæ	20	8	43	+ 14	50	0
24·49	− 7·77	6·0	...	15		Sagittæ	19	58	43	+ 16	44	8
24·52	+ 17·72	5·3	5·9	5	ι	Delphini	20	32	5	+ 10	57	6
24·56	+ 9·75	5·3	...			Lyræ	18	54	52	+ 26	3	9
24·78	+ 9·47	5·5	...			„	18	56	25	+ 26	7	3
24·80	+ 21·42	4·9	...	104	A	Herculis	18	7	23	+ 31	22	6
25·32	− 15·98	5·2	5·8	3	η	Delphini	20	28	16	+ 12	37	0
25·78	− 5·36	3·6	...	12	γ	Sagittæ	19	53	25	+ 19	10	0
25·85	+ 16·96	5·4	...			Lyræ	18	28	15	+ 30	27	9
26·28	+ 4·05	6·0	...			Vulp., 3 Cygni	19	20	28	+ 24	41	8
26·43	+ 3·27	4·7	...	6		Vulpeculæ	19	23	43	+ 24	25	4
...	...	5·8	...			„	19	23	57	+ 24	31	4
26·91	− 15·27	4·7	5·2	4	ζ	Delphini	20	29	42	+ 14	15	7
27·05	− 6·33	5·4	...	16	η	Sagittæ	19	59	50	+ 19	38	9

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h	m	s	δ 1880. °	′
°	°	m	m								
27·13	+ 5·23	5·0	...	3		Vulpeculæ	19	17	56	+26	2·0
27·17	−15·76	3·7	3·5 *d*	6	β	Delphini	20	31	55	+14	10·7
27·32	−10·53	6·2	6·2			Aquilæ	20	14	54	+17	25·0
27·40	− 2·15	5·0	...	12		Vulpeculæ	19	45	54	+22	18·4
27·43	+ 9·53	5·5	...			Lyræ	19	1	52	+28	26·4
28·09	+15·57	5·5	...			„	18	39	21	+31	48·6
28·30	+20·48	5·4	5·9	16		Delphini	20	49	55	+12	6·6
28·41	+14·55	5·8	...			Lyræ	18	43	26	+31	37·5
28·44	−15·30	5·9	...			Delphini	20	33	31	+15	25·0
28·48	−16·60	4·6	4·5	11	δ	„	20	37	51	+14	38·7
28·58	−15·36	4·0	...	9	α	„	20	34	4	+15	29·4
28·85	− 3·43	5·7	...	14		Vulpeculæ	19	54	2	+22	46·5
28·93	− 1·80	4·7	...	13		„	19	48	22	+23	46·0
28·97	+17·43	5·3	...			Lyræ	18	32	13	+33	22·1
29·15	+ 0·97	5·4	...	10		Vulpeculæ	19	38	44	+25	29·1
29·26	− 1·87	5·6	...			„	19	49	26	+24	0·3
29·26	−19·75	5·4	5·6	17		Delphini	20	49	56	+13	15·9
29·33	+14·52	5·1	...	9	ν_2	Lyræ	18	45	24	+32	24·8
29·50	+ 4·60	3·1	...	6	β	Cygni	19	25	53	+27	42·5
...	...	5·2	...			„	19	25	55	+27	42·8
29·51	− 1·03	5·8	...			Vulpeculæ	19	46	59	+24	41·1
29·55	+14·66	5·6	...	8	ν_1	Lyræ	18	45	18	+32	40·5
29·78	−16·50	4·2	... *d*	12	γ	Delphini	20	41	6	+15	41·6
29·80	+18·10	5·9	...			Lyræ	18	30	53	+34	21·7
29·93	+12·43	5·1	...	15	λ	„	18	55	29	+31	58·7
30·06	+11·31	5·7	...			„	19	0	24	+31	33·9
30·10	+21·61	4·4	...	1	κ	„	18	15	39	+36	0·7
30·11	+14·83	var.	3·4 − 4·5 *d*	10	β	„	18	45	39	+33	13·5
30·19	+ 6·68	4·9	...	2		Cygni	19	19	24	+29	23·3
30·27	− 4·60	5·3	...	17		Vulpeculæ	20	1	44	+23	16·2
30·33	+12·87	3·3	...	14	γ	Lyræ	18	54	27	+32	31·5
30·34	+13·34	5·3	...			„	18	52	31	+32	44·9
30·34	+ 9·81	5·7	...	19		„	19	7	10	+31	5·0
30·58	− 2·96	5·9	...			Vulpeculæ	19	56	40	+24	28·1
30·73	− 2·94	5·4	...	16		„	19	56	56	+24	36·2
30·91	+ 1·08	var.	3 − ?	11		„ Nova 1670	19	42	39	+27	1·2
31·00	+11·20	4·9	...	17		Lyræ	19	2	53	+32	18·8
31·03	− 9·41	5·9	...			Vulpeculæ	20	20	22	+21	1·1

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h m s	δ 1880. ° ′
°	°	m	m					
31·25	+ 4·59	5·4	...		9	Cygni	19 30 5	+29 12·0
31·25	+15·12	var.	6·4–7·3			U Delphini	20 39 59	+17 39·3
31·33	− 6·27	5·5	...		22	Vulpeculæ	20 10 19	+23 8·6
32·36	+ 4·11	4·9	...		12	φ Cygni	19 34 38	+29 52·7
32·45	− 5·83	5·5	...		24	Vulpeculæ	20 11 39	+24 18·1
32·71	−11·91	4·8	...		29	„	20 33 10	+20 46·8
32·94	− 1·17	4·9	...		15	„	19 56 10	+27 25·4
32·99	− 6·92	5·4	...		25	„	20 16 54	+24 4·0
33·00	− 5·01	4·8	...		16	Hev. „	20 10 11	+25 13·6
33·29	− 3·90	5·9	...	cum.	20	„	20 6 59	+26 7·3
33·30	−11·65	5·9	...			„	20 33 51	+21 23·7
33·45	− 3·38	5·5	...		18	„	20 5 33	+26 33·0
33·53	− 3·66	5·8	...		19	„	20 6 47	+26 27·1
33·64	+17·60	4·3	...		6	ζ_1 Lyræ	18 40 38	+37 28·8
...	...	5·9	...		7	ζ_2 „	18 40 40	+37 28·2
33·81	+15·71	5·3	...		11	δ_1 „	18 49 32	+36 49·3
33·82	+15·54	4·5	...		12	δ_2 „	18 50 18	+36 44·8
33·90	+22·03	4·9	...		2	μ „	18 20 17	+39 26·6
34·14	+19·48	0·2	...		3	α „	18 32 53	+38 40·4
34·30	+12·77	5·2	...		18	ι „	19 3 1	+35 54·8
34·60	−17·07	6·1	...			Delphini	20 54 59	+18 51·8
34·67	+ 4·71	5·8	...			Cygni	19 38 8	+32 8·6
34·87	− 3·79	4·8	...		23	Vulpeculæ	20 10 48	+27 26·8
35·02	− 0·38	5·8	...			Cygni	19 58 41	+29 34·6
35·04	−10·10	5·1	...		28	Vulpeculæ	20 33 18	+23 41·7
35·22	+ 7·71	4·8	...		8	Cygni	19 27 19	+34 11·9
35·31	+ 1·09	5·4	...			„	19 53 52	+30 39·5
35·38	− 3·00	5·3	...		21	Vulpeculæ	20 9 19	+28 19·9
35·41	+15·50	5·9	...			Lyræ	18 53 55	+38 6·3
35·54	+18·47	4·6	... *d*		5	ϵ_2 „	18 40 24	+39 29·3
35·60	+18·50	4·6	... *d*		4	ϵ_1 „	18 40 22	+39 32·7
35·98	+ 3·58	var.	4·0–?			χ Cygni	19 45 57	+32 36·7
36·21	+ 4·75	5·0	...		17	„	19 41 52	+33 26·9
36·28	+ 9·64	5·1	...		4	„	19 21 50	+36 4·7
36·61	−14·73	5·8	...		33	Vulpeculæ	20 52 55	+21 51·8
36·67	+ 8·78	5·8	...			Cygni	19 26 26	+35 58 6
36·69	− 8·37	5·6	...		27	Vulpeculæ	20 31 58	+26 2·7
36·88	−10·48	5·1	...		30	„	20 39 41	+24 50·5

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880 h	m	s	δ 1880 °	′	″
36·94	+12·21	4·3	...	21 θ Lyræ	19	12	12	+37	55	3
37·05	+ 0·74	5·5	...	Cygni	19	59	54	+31	52	8
37·47	+18·86	5·7	...	Lyræ	18	42	23	+41	18	8
37·63	+13·14	4·5	...	20 η „	19	9	40	+38	56	4
37·74	+16·39	6·1	...	„	18	54	51	+40	30	9
37·81	+ 8·27	6·0	...	11 Cygni	19	31	30	+36	40	7
38·30	+17·44	5·4	...	Lyræ	18	51	2	+41	27	0
38·44	+ 3·78	4·0	...	12 η Cygni	19	51	48	+34	45	9
38·58	−20·53	4·3	...	1 Pegasi	21	16	32	+19	17	5
38·71	− 4·62	4·1	...	41 Cygni	20	24	30	+29	58	1
39·04	+ 7·05	5·0	...	15 „	19	39	57	+37	3	9
39·06	+15·43	6·0	...	Lyræ	19	2	24	+41	13	7
39·16	− 2·23	4·6	...	39 Cygni	20	19	4	+31	48	2
39·37	−10·54	4·7	...	31 Vulpeculæ	20	46	59	+26	38	9
39·59	− 0·23	5·8	...	Cygni	20	10	44	+33	22	0
39·87	+ 5·08	5·7	...	„	19	50	25	+36	40	8
39·96	−18·68	6·0	...	Pegasi	21	14	47	+21	31	1
40·15	− 9·68	var.	5·5−6·5	T Vulpeculæ	20	46	23	+27	28	1
40·36	+ 2·59	5·5	...	27 b_1 Cygni	20	1	54	+35	38	9
40·46	−10·32	5·1	...	32 Vulpeculæ	20	49	27	+27	36	1
40·48	+ 4·26	5·2	...	25 Cygni	19	55	31	+36	42	9
40·58	+18·31	var.	4·0−4·7	13 R Lyræ	18	51	41	+43	47	3
40·74	− 5·23	6·3	5·6	48 Cygni	20	32	39	+31	9	2
...	...	6·4		„	20	32	40	+31	6	2
40·87	+ 6·72	5·5	...	19 „	19	46	19	+38	24	8
41·00	− 0·02	5·2	...	35 „	20	14	3	+34	36	5
41·21	− 7·11	4·3	...	52 „	20	40	43	+30	16	6
41·24	+ 5·73	4·7	...	22 „	19	51	34	+38	10	1
41·30	+ 8·94	6·1	...	„	19	37	51	+39	58	2
41·40	+ 2·58	4·8	...	28 b_2 „	20	4	58	+36	29	2
41·48	−17·53	5·8	...	Pegasi, 34 Vulp.	21	15	39	+23	21	1
41·79	− 5·33	5·8	...	49 Cygni	20	36	11	+31	52	9
41·97	+ 1·73	5·0	...	29 b_2 „	20	10	2	+36	26	4
42·28	−17·71	5·6	...	Pegasi	21	18	34	+23	45	5
42·40	+13·41	6·0	...	Lyræ	19	20	9	+43	9	3
42·48	+ 7·72	5·5	...	Cygni	19	46	30	+40	17	7
42·49	+11·21	5·2	...	„	19	30	47	+42	9	0
42·59	+ 1·21	5·6	...	36 „	20	13	59	+36	37	5

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.			Star.		α 1880. h	m	s	δ 1880. °	′
°	°	m	m									
42·80	+ 9·44	6·1	...			Cygni		19	39	45	+ 41	49·1
42·84	− 19·12	4·8	...	2		Pegasi		21	24	31	+ 23	6·8
42·97	+ 6·54	5·6	...			Cygni		19	53	4	+ 40	2·8
43·13	− 2·32	4·8	...	47		„		20	29	14	+ 34	50·4
43·30	+ 10·66	5·3	...	14		„		19	35	32	+ 42	32·5
43·33	+ 1·93	var. 3 − < 6		34	P	„	Nova 1600	20	13	22	+ 37	38·6
43·40	+ 3·05	var. 6·5? −			RS	„		20	9	2	+ 38	22·1
43·49	− 0·84	6·0	...	42		„		20	24	46	+ 36	3·3
43·61	+ 0·67	5·7	...			„		20	19	15	+ 37	5·4
43·75	− 5·07	2·7	...	53	ε	„		20	41	21	+ 33	31·3
43·78	− 16·46	5·8	...			Vulpeculæ		21	19	14	+ 25	39·5
43·94	+ 18·52	5·0	...	16		Lyræ		18	58	3	+ 46	45·9
44·19	− 11·15	5·5	...			Cygni		21	3	33	+ 29	43·3
42·21	− 4·97	var. 5·5? − 6?			T	„		20	42	23	+ 33	56·0
44·33	− 6·53	5·8	...			„		20	49	2	+ 32	58·9
44·58	− 10·12	6·0	...			„		21	1	28	+ 30	42·2
44·62	− 3·59	var. 6·4 − 7·7			X	„		20	38	42	+ 35	9·3
44·70	+ 12·03	5·2	...			„		19	32	55	+ 44	25·8
44·83	+ 0·66	5·5	...	40		„		20	23	8	+ 38	2·8
44·86	− 11·78	3·5	...	64	ζ	„		21	7	50	+ 29	44·1
45·12	+ 3·46	5·5	...			„		20	12	39	+ 39	59·7
45·14	+ 16·15	6·1	...			„		19	13	25	+ 46	46·5
45·22	− 15·80	5·4	...	35		Vulpeculæ		21	22	23	+ 27	5·2
45·24	− 22·15	5·4	...	12		Pegasi		21	40	33	+ 22	23·8
45·36	+ 20·29	5·9	...			Draconis		18	51	37	+ 48	42·6
45·64	+ 2·56	2·3	...	37	γ	Cygni		20	17	55	+ 39	52·4
45·80	+ 11·81	5·1	...			„		19	37	8	+ 45	14·4
45·84	+ 10·98	3·0	...	18	δ	„		19	41	13	+ 44	50·3
45·84	− 3·62	4·6	...	54	λ	„		20	42	44	+ 36	3·0
46·31	+ 2·97	6·0	...			„		20	18	30	+ 40	38·6
46·89	− 19·91	4·2	...	10	κ	Pegasi		21	39	13	+ 25	5·6
47·11	+ 21·19	4·9	...			Draconis		18	50	15	+ 50	33·6
47·36	+ 20·06	5·4	...			„		18	57	13	+ 50	21·8
47·48	+ 18·07	5·8	... *d*			Cygni		19	8	59	+ 49	37·9
47·74	+ 24·56	5·4	... *d*			Draconis		18	31	11	+ 52	15·5
7·75	+ 9·18	5·7	...			Cygni		19	55	34	+ 45	26·7
47·88	− 11·35	6·1	...			„		21	16	19	+ 32	6·2
48·13	+ 10·92	5·6	...			„		19	48	22	+ 46	43·1

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1885			δ 1885	
°	°	m	m				h	m	s	°	′
48·62	−20·93	5·0	...	16	Pegasi		21	47	36	+25	21·7
48·67	−12·61	5·7	...		Cygni		21	23	1	+31	42·0
48·93	+11·38	5·8	...		,,		19	48	35	+47	37·3
48·94	−17·49	4·4	... *d*	78	μ ,,		21	38	47	+28	12·1
48·97	− 9·20	4·4	...	66	τ ,,		21	12	59	+34	23·6
49·11	+ 0·60	5·5	...		,,		20	37	36	+41	17·3
49·25	+ 6·67	5·8	...		,,		20	12	7	+45	12·7
49·33	+15·51	5·7	...		,,		19	28	9	+50	3·0
49·64	+14·74	4·6	...	13	θ ,,		19	33	13	+49	56·6
49·66	+14·68	var. 5·9−?			R ,,		19	33	36	+49	55·8
49·95	− 4·89	5·1	... *d*	61	,,		21	1	32	+38	9·5
49·97	+ 7·68	3·8	...	31	o_1 ,,		20	9	51	+46	22·7
49·99	+ 7·77	4·9	...	30	,,		20	9	32	+46	27·2
50·06	+ 5·94	5·8	...		,,		20	18	10	+45	24·6
50·31	+ 9·80	6·0	...		,,		20	0	53	+47	53·0
50·36	+14·14	5·5	...	16	*c* ,,	6·2	19	38	37	+50	14·8
...	...				,,	6·3	19	38	40	+50	14·4
50·42	+15·52	5·6	...		,,		19	31	13	+50	58·8
50·46	−18·64	5·6	...	15	Pegasi		21	47	9	+28	13·9
50·48	+20·50	5·4	...	51	Draconis		19	2	13	+53	12·8
50·52	+16·38	3·9	...	10	ι Cygni		19	26	41	+51	28·5
50·59	− 1·91	4·1	...	58	ν ,,		20	52	42	+40	42·3
50·71	− 6·51	3·9	...	65	τ ,,		21	10	0	+37	32·0
50·88	−23·34	4·0	...	24	ι Pegasi		22	1	25	+24	45·6
50·90	−17·20	5·0	...	14	,,		21	44	32	+29	37·0
50·91	+16·96	5·7	...	7	Cygni		19	24	30	+52	4·6
50·95	+ 7·99	4·1	...	32	o_2 ,,		20	11	46	+47	20·8
51·20	+18·82	3·9	...	1	κ ,,		19	14	20	+53	8·8
51·37	− 9·01	5·8	...	69	,,		21	20	53	+36	9·0
51·49	+24·27	5·2	...	46	*c* Draconis		18	40	19	+55	25·1
51·63	+11·25	5·2	...	26	*e* Cygni		19	57	58	+49	46·3
51·77	+ 2·97	1·5	...	50	α ,,		20	37	20	+44	51·1
51·85	+ 1·01	5·0	...	56	,,		20	45	49	+43	36·5
51·91	− 8·89	5·1	...	70	,,		21	22	28	+36	35·8
52·03	+ 4·88	5·6	...		,,		20	29	59	+46	16·9
52·04	− 5·89	4·3	...	67	σ ,,		21	12	42	+38	53·5
52·48	+ 0·81	4·6	...	57	,,		20	49	0	+43	56·0
52·51	+21·89	5·7	...	49	Draconis		18	58	21	+55	29·2

Galactic Long.	Lat.	Magn. H.P.	U.A.		Star.	α 1880. h	m	s	δ 1880. °	′
°	°	m	m							
52·96	−20·26	5·5	...	23	Pegasi	22	0	8	+28	22·9
53·07	+ 1·33	5·6	...		Cygni	20	49	7	+44	43·7
53·13	+12·57	6·0	...		,,	19	56	5	+51	43·6
53·15	+ 0·20	5·9	...		,,	20	54	2	+44	0·3
53·17	+13·25	4·8	...	24	ψ ,,	19	52	32	+52	7·2
53·25	+14·18	5·0	...	20	*d* ,,	19	47	37	+52	41·0
53·26	+ 2·53	5·0	...	55	,,	20	44	51	+45	40·2
53·40	+ 6·79	5·0	...	45	ω_1 ,,	20	26	21	+48	32·8
53·44	+ 7·44	5·6	...	53	,,	20	23	22	+48	59·2
53·58	− 1·03	3·7	...	62	ξ ,,	21	0	34	+43	27·0
53·74	+ 6·79	5·6	...	46	ω_2 ,,	20	27	37	+48	48·9
53·97	− 8·80	5·0	...	72	,,	21	29	52	+37	59·8
54·17	+16·68	5·7	...		,,	19	35	59	+54	41·5
54·30	+20·90	5·2	...	53	Draconis	19	9	24	+56	39·3
54·31	− 3·51	6·0	...		Cygni	21	12	51	+42	10·8
54·42	+ 3·80	5·5	...		,,	20	43	52	+47	23·4
54·67	−12·29	5·7	...		,,	20	3	4	+52	49·0
54·73	+ 1·00	5·2	...	60	,,	20	57	0	+45	41·1
55·02	+ 2·52	5·8	...		,,	20	51	47	+46	57·5
55·13	−10·08	5·5	...	79	,,	21	38	28	+37	44·1
55·27	+20·94	5·3	...	54	Draconis	19	11	47	+57	29·9
55·32	− 2·73	5·0	...	68 A	Cygni	21	13	59	+43	26·5
55·51	+ 2·10	4·6	...	59	f_1 ,,	20	55	45	+47	3·2
55·53	− 7·64	5·1	...	74	,,	21	32	8	+39	52·5
55·55	+20·13	6·0	...		Draconis	19	18	4	+57	25·1
55·60	−22·77	4·9	...	32	Pegasi	22	15	47	+27	43·6
55·74	+ 6·13	5·4	...	51	Cygni	20	38	31	+49	54·6
55·90	+24·30	4·6	...	47	*o* Draconis	18	49	26	+59	14·5
56·14	−10·42	5·8	...		Cygni	21	43	30	+38	5·5
56·20	+ 8·69	6·0	...		,,	20	27	56	+51	54·1
56·24	−17·31	5·7	...	27	Pegasi	22	3	55	+32	35·2
56·38	−17·40	4·4	...	29	π ,,	22	4	40	+32	35·4
56·44	+ 1·36	5·1	...	63	f_2 Cygni	21	2	28	+47	10·0
56·76	− 7·79	5·3	...	77	,,	21	37	33	+40	31·8
56·91	− 7·82	5·5	...		,,	21	38	17	+40	36·4
57·52	+16·12	5·1	...	23	,,	19	50	50	+57	12·6
57·52	+ 4·69	5·9	...		,,	20	52	37	+50	16·1
57·55	+ 4·27	5·5	... *d*		,,	20	54	39	+49	59·8

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h	m	s	δ 1880. °	′
		m	m								
57°58	+12°05	5·7	...		Cygni		20	15	27	+55	1·3
57·73	−16·56	5·4	...		Pegasi		22	7	29	+34	0 8
57·79	− 6·35	var. 3	−?		Cygni.	Nova 1876	21	37	0	+42	17·7
57·84	− 5·83	5·3	...	75		„	21	35	29	+42	43·8
58·09	− 1·51	5·5	...			„	21	20	55	+46	11·7
58·16	+13·30	4·4	...	33		„	20	10	36	+56	12·0
58·49	− 3·34	4·2	...	73	ρ	„	21	29	28	+45	3·7
58·50	− 2·11	5·3	...	71	g	„	21	25	1	+46	0·7
58 61	− 3·74	var. 6·1	−6·7		W	„	21	31	29	+44	50·3
58·89	+16·48	5·2	...		Cephei		19	53	38	+58	31·5
59·07	+11·19	5·9	...		Cygni		20	26	27	+55	39·9
59·26	+ 1·21	5·4	...			„	21	15	21	+49	0·2
59·48	+ 0 84	5·8	...			„	21	17	50	+48	52·5
59·52	+17·16	6·0	...			„	19	51	27	+59	23·5
59·70	− 0·10	5·3	...			„	21	22	36	+48	18·8
60·09	−14·30	4·1	...	1		Lacertæ	22	10	44	+37	9·1
60·11	− 0·99	cum.		Mess. 39		Cygni	$6^m·5$	21	27	57	+47	54·9
60·14	− 0·82						$6^m·3$	21	27	24	+48	3·4
60·85	−12·43	4·6	...	1 Hev.		Lacertæ	22	8	43	+39	7·2
61·05	+ 5·12	5·7	...			Cygni	21	6	33	+53	4·4
61·06	−23·63	3·1	...	44	η	Pegasi	22	37	23	+29	35·6
61·20	+ 0·11	5·7	...			Cygni	21	28	42	+49	26·7
61·65	+10·43	4·6	...	6 Hev.		Cephei	20	42	22	+57	9·0
61·96	− 7·21	5·6	...			Lacertæ	21	58	6	+44	4·3
62·07	+ 4·73	6·0	...			Cygni	21	13	17	+53	29·6
62·10	+ 8·85	6·1	...			Cephei	20	53	4	+56	25·5
62·35	+17·05	5·6	...	66		Draconis	20	3	38	+61	38·8
62·41	+ 2·92	5·7	...			Cygni	21	22	48	+52	22·7
62·49	+ 8·11	5·9	...			Cephei	20	58	51	+56	11·8
62·51	− 1·83	4·4	...	81	π_2	Cygni	21	42	22	+48	45·3
62·62	− 7·22	5·3	...			Lacertæ	22	1	10	+44	25·8
62·79	− 9·81	5·7	...			„	22	9	42	+42	21·5
62·81	+16·49	5·7	...	68		Draconis	20	9	37	+61	42·9
62·83	+ 2 62	5·9	...			Cygni	21	26	21	+52	25·8
63·09	+ 0·11	4·9	...	80	π_1	„	21	37	50	−50	38·6
63·17	− 13·73	6·1	...			Lacertæ	22	22	11	+39	11·9
63·50	+15·80	5·6	...	71		Draconis	20	17	36	+61	52·6
63·54	+12 77	5·9	...			Cephei	20	37	45	+60	4·3

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ 1880. ° ′
63·62	+ 23·10	4·6	...	58 π	Draconis	19 20 3	+ 65 90·2
64·01	− 7·63	5·8	...		Lacertæ	22 8 53	+ 44 50·7
64·01	− 14·24	5·6	...		,,	22 27 8	+ 39 9·8
64·17	− 16·83	6·0	...		,,	22 34 9	+ 36 58·1
64·30	+ 10·26	5·8	...		Cephei	20 56 28	+ 58 58·2
64·53	− 14·69	5·3	... *d*	8	Lacertæ	22 30 32	+ 39 0 8
64·68	+ 18·86	5·4	...	64 ε	Draconis	20 0 12	+ 64 29·1
64·81	+ 15 28	4·3	...	2 θ	Cephei	20 27 34	+ 62 35·5
64·84	− 15·52	5·0	...	10	Lacertæ	22 33 53	+ 38 25·6
64·97	+ 13·11	3·6	...	3 η	Cephei	20 42 51	+ 61 22·4
65·10	+ 16·61	5 8	...		Draconis	20 19 29	+ 63 35·7
65·34	+ 24·51	3·2	...	57 δ	,,	19 12 31	+ 67 27·0
65·38	− 11·16	4·6	...	6	Lacertæ	22 25 18	+ 42 30·5
65·51	+ 7·86	5·7	...		Cephei	21 15 56	+ 58 7·0
65·67	− 7·36	4·8	...	2	Lacertæ	22 16 4	+ 45 56·0
65·79	+ 9·50	5·5	...		Cephei	21 8 45	+ 59 29·6
65·80	− 14·68	5·1	...	12	Lacertæ	22 36 6	+ 39 35·9
66·53	− 0·36	5·6	...		Cygni	21 57 27	+ 52 18·2
66·57	− 2·86	5·4	...		Lacertæ	22 6 30	+ 50 13·9
66·61	− 19·40	5·6	...		,,	22 50 9	+ 35 42·7
66·72	+ 5·28	5·5	...	13 Hev.	Cephei	21 35 14	+ 56 56·8
66·80	− 18·68	6·0	...		Lacertæ	22 49 28	+ 36 26·2
67·01	− 13·49	5·1	...	13	,,	22 38 44	+ 41 11·4
67·09	+ 2·86	5·5	...		Cygni	21 47 57	+ 55 14·8
67·48	+ 20·23	4 6	...	67 ρ	Draconis	20 2 16	+ 67 31·9
67·52	− 7·08	4·6	...	5	Lacertæ	22 24 32	+ 47 5·6
67·56	− 11·01	4·7	...	11	,,	22 35 15	+ 43 39·0
67·69	− 5·14	4·6	...	4	,,	22 19 39	+ 48 52·1
67·87	+ 8·21	5·4	...		Cephei	21 27 42	+ 59 55·8
67·89	+ 3·26	6·1	...	13	,,	21 50 51	+ 56 2·6
68·00	+ 5·91	var. 4?−5?		μ	,,	21 39 50	+ 58 13·8
68·12	+ 23·52	4·7	...	61 σ	Draconis	19 32 35	+ 69 27·4
68·14	− 13·89	5·8	...	14	Lacertæ	22 44 57	+ 41 19·1
68·24	+ 10·78	2·6	...	5 α	Cephei	21 15 43	+ 62 4·6
68·29	− 16·88	6·1	...		Lacertæ	22 52 8	+ 38 40·0
68·60	− 11·22	5·7	...		,,	22 40 51	+ 43 54·8
68·76	+ 16·31	5·5	...	4	Cephei	20 41 41	+ 66 13·3
68·96	− 2·68	4·5	...	3	Lacertæ	22 18 51	+ 51 37·7

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ 1880. ° ′
°	°	m	m				
69·03	−12·80	5·1	...	15	Lacertæ	22 46 37	+42 40·5
69·04	− 4·98	3·9	...	7	„	22 26 21	+49 39·9
69·04	−14·69	5·6	...	16	„	22 50 55	+40 57·6
69·25	+22·47	3·9	...	63 ε	Draconis	19 48 35	+69 57·7
69·36	+19·37	6·1	...		„	20 19 34	+68 29·8
69·49	+ 3·82	5·5	...	14	Cephei	21 58 3	+57 25·3
69·58	+ 8·89	4·8	...	9	„	21 34 42	+61 32·4
69·60	+ 7·11	5·6	...	12	„	21 43 53	+60 8·8
69·67	+ 7·58	4·5	...	10 ν	„	21 41 59	+60 34·0
69·92	+ 2·13	5·4	...		„	22 7 29	+56 14·6
69·92	−11·62	5·7	...		Lacertæ	22 48 18	+44 6·7
69·93	+12·35	5·3	...	6	Cephei	21 16 53	+64 21·8
70·31	−14·44	3·8	...	1 ο	Andromedæ	22 56 24	+41 40·9
70·40	+ 2·07	4·2	...	23 ε	Cephei	22 10 37	+56 26·7
70·46	+ 8·67	6·0	...		„	21 41 36	+61 54·5
70·49	− 4·32	4·8	...	9	Lacertæ	22 32 27	+50 55·5
70·56	+ 3·34	3·5	...	21 ζ	Cephei	22 6 42	+57 36·6
70·61	−14·09	5·1	...	2	Andromedæ	22 57 5	+42 6·8
71·30	+ 4·31	5·3	...	22 λ	Cephei	22 7 24	+58 49·4
71·91	−15·57	var. 5·6 − 10		T	„	21 7 57	+68 0·2
71·94	− 2·48	6·0	...		Lacertæ	22 35 26	+53 13·2
71·95	+13·15	5·4	...	7	Cephei	21 25 27	+66 17·1
72·06	− 8·27	5·1	...		Lacertæ	22 51 47	+48 2·6
72·09	+ 5·40	5·4	...		Cephei	22 8 4	+60 10·0
72·24	− 2·56	6·0	...		Lacertæ	22 37 26	+53 16·9
72·25	+ 7·12	5·2	...	19	Cephei	22 1 27	+61 41·8
72·25	+ 8·78	5·2	...		„	21 53 16	+63 3·3
72·25	−19·81	5·8	...	12	Andromedæ	23 15 6	+37 31·6
72·29	−13·90	5·9	...	6	„	23 4 55	+42 54·0
72·40	+ 0·42	var. 5·8 − 6·8		W	Cephei	22 29 1	+56 0·3
72·44	− 7·27	5·2	...		Lacertæ	22 51 10	+49 5·6
72·53	+ 7·55	5·4	...	20	Cephei	22 1 22	+62 12·0
72·61	+ 7·90	5·4	...	18	„	22 0 17	+62 32·2
...	...	6·6	...		„	22 24 42	+57 47·4
72·73	+ 2·28	var. 3·7 − 4·9		27 δ	„	22 24 43	+57 48·1
72·88	−11·08	5·7	...	4	Andromedæ	23 2 10	+45 44·3
73·05	−16·07	6·0	...	9	„	23 12 42	+41 7·1
73·08	+ 0·25	5·6	...		Cephei	22 33 55	+56 10·3

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h	m	s	δ 1880. °	′	″
°	°	m	m									
73·31	− 2·52	6·0	...			Lacertæ	22	43	49	+ 53	46	9
73·47	+ 9·14	4·4	... *d*	17	ξ	Cephei	22	0	19	+ 64	2	6
73·71	− 7·47	4·9	...	3		Andromedæ	22	58	48	+ 49	24	0
73·97	− 8·38	5·9	...	5		,,	23	2	19	+ 48	38	5
73·99	+ 17·75	6·0	...			Cephei	21	5	40	+ 70	57	0
74·07	− 1·23	5·4	...			,,	22	44	49	+ 55	16	0
74·64	− 19·25	5·3	...	14		Andromedæ	23	25	23	+ 38	34	6
74·65	+ 15·84	3·4	...	8	β	Cephei	21	27	6	+ 70	2	0
74·75	− 8·56	4·7	...	7		Andromedæ	23	7	3	+ 48	45	0
75·02	− 15·51	5·8	...	13		,,	23	21	21	+ 42	15	1
75·35	+ 21·88	5·1	...	73		Draconis	20	33	4	+ 74	32	6
75·42	− 9·21	4·9	...	8		Andromedæ	23	12	11	+ 48	21	6
75·57	− 9·68	5·3	...	11		,,	23	13	55	+ 47	58	0
75·61	− 18·48	5·5	...	15		,,	23	28	45	+ 39	34	5
75·80	− 0·86	5·6	...			Cassiopeiæ	22	55	2	+ 56	18	1
75·86	+ 8·23	5·6	...	26		Cephei	22	23	14	+ 64	31	2
76·00	+ 15·67	4·8	...	11		,,	21	40	10	+ 70	45	5
76·21	+ 6·27	5·2	...	30		,,	22	34	24	+ 62	57	7
76·67	− 5·19	5·6	...			Andromedæ	23	11	14	+ 52	34	0
76·69	+ 3·94	5·8	...			Cephei	22	46	42	+ 61	3	5
76·76	+ 16·38	5·4	...			,, , 78 Drac.	21	41	36	+ 71	46	2
77·13	− 15·75	4·3	...	17	ι	Andromedæ	23	32	15	+ 42	36	2
77·22	+ 13·30	5·5	...			Cephei	22	7	54	+ 69	32	4
77·23	+ 24·40	4·4	...	1	κ	,,	20	12	54	+ 77	21	0
77·48	− 1·29	5·5	...			Cassiopeiæ	23	7	31	+ 56	30	4
77·53	+ 1·11	5·0	...	1		,,	23	1	33	+ 58	46	3
77·82	− 14·82	4·4	...	19	κ	Andromedæ	23	34	30	+ 43	40	2
77·87	+ 0·89	5·4	...	2		Cassiopeiæ	23	4	36	+ 58	40	9
77·89	− 12·62	4·0	...	16	λ	Andromedæ	23	31	42	+ 45	48	5
78·30	− 16·30	5·2	...	16		Cephei	21	57	32	+ 72	36	5
78·44	+ 15·16	5·0	...	24		,,	22	7	30	+ 71	45	0
78·44	+ 8·09	3·6	...	32	ι	,,	22	45	25	+ 65	34	2
78·68	+ 13·15	5·7	...			,,	22	22	54	+ 70	9	6
78·76	+ 12·11	6·0	...			,,	22	29	34	+ 69	17	5
79·20	− 8·83	5·3	...	18		Andromedæ	23	33	20	+ 49	48	4
79·20	+ 15·83	6·0	...			Cephei	22	10	42	+ 72	42	6
79·33	− 13·04	5·0	...	20	ψ	Andromedæ	23	40	5	+ 45	45	2
79·65	+ 1·10	6·0	...			Cassiopeiæ	23	17	12	+ 59	28	5

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
80°10	− 0°69	m 4 8	m ...	1 Hev.	Cassiopeiæ	23	24	30	+ 57	53	3
80·12	+ 8·47	5·4	...		Cephei	22	58	59	+ 66	33	8
80·50	− 17·13	6·0	...		Andromedæ	23	50	59	+ 41	59	4
80·58	+ 3·07	5·2	...	4	Cassiopeiæ	23	19	31	+ 61	37	4
80·82	+ 15·27	5·3	...	31	Cephei	22	32	48	+ 73	1	2
81·80	+ 8·80	4·9	...*d*	34 *o*	„	23	13	42	+ 67	27	3
81·83	− 17·93	5·9	...		Andromedæ	23	58	27	+ 41	25	5
81·96	+ 17·62	5·7	...		Cephei	22	30	10	+ 75	36	5
82·00	− 2·32	5·7	...		Cassiopeiæ	23	41	10	+ 56	47	1
82·27	− 1·16	5·2	...	5 *τ*	„	23	41	12	+ 57	59	0
82·40	− 8·60	var. 4·8	− ?	R	„	23	52	19	+ 50	43	2
82·49	+ 11·50	5·5	...		Cephei	23	11	0	+ 70	14	0
82·73	− 4·26	5·5	...		Cassiopeiæ	23	51	6	+ 55	2	3
82·97	− 2·48	4·6	...	7 *ρ*	„	23	48	24	+ 56	49	9
83·08	+ 19·97	5·8	...	28	Cephei	12	25	47	+ 78	10	4
83·24	+ 19·92	5·4	...	29 *ρ*	„	22	28	48	+ 78	12	5
83·26	+ 2·27	5·5	...	6	Cassiopeiæ	23	43	0	+ 61	32	8
83·28	− 4·32	5·0	...*d*	8 *σ*	„	23	52	56	+ 55	5	2
83·36	+ 10·53	5·7	...		Cephei	23	22	13	+ 69	42	0
83·41	− 19·22	5·8	...	23	Andromedæ	0	7	17	+ 40	22	4
83·51	− 14·15	4·9	...	22	„	0	4	5	+ 45	24	3
83·60	+ 14·67	5·6	...		Cephei	23	10	21	+ 73	34	6
83·61	+ 15·91	4·5	...	33 *π*	„	23	4	5	+ 74	44	3
83·82	− 21·64	4·3	...	24 *θ*	Andromedæ	0	10	50	+ 38	0	9
83·85	− 23·56	4·6	...	25 *σ*	„	0	12	4	+ 36	7	2
84·03	+ 6·78	6·0	...		Cephei	23	40	54	+ 66	6	9
84·28	− 16·75	6·0	...		Andromedæ	0	10	4	+ 42	55	7
84·38	+ 7·74	5·1	...	51 Hev.	Cephei	23	42	11	+ 67	8	4
84·56	+ 1·01	5·7	...		Cassiopeiæ	23	55	30	+ 60	33	3
84·58	− 22·44	5·3	...	27 *ρ*	Andromedæ	0	14	48	+ 37	18	2
84·75	− 16·60	5·9	...	26	„	0	12	23	+ 43	7	5
84·94	− 12·44	5·8	...		„	0	10	49	+ 47	16	8
84·98	+ 1·04	6·0	...		Cassiopeiæ	23	58	55	+ 60	38	7
85·15	− 1·18	2·4	...	11 *β*	„	0	2	47	+ 58	29	3
85·20	+ 13·94	6·0	...		Cephei	23	24	8	+ 73	20	3
85·26	− 21·89	var. 5·6	− ?	R	Andromedæ	0	17	42	+ 37	54	8
85·57	+ 3·86	5·5	...	10	Cassiopeiæ	0	0	13	+ 63	31	7
85·65	+ 6·86	5·8	...		Cephei	23	58	29	+ 66	29	8

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ ° ′
°	°	m	m				
86·17	+17·44	3·4	...		γ Cephei	23 34 26	+76 57·8
86·17	+23·34	4·8	...		„	22 47 54	+82 31·0
86·42	+ 1·05	5·8	...		Cassiopeiæ	0 10 31	+60 51 0
86·50	− 8·50	5·4	...		„	0 17 48	+51 21·3
86·58	−16·15	5·2	...		Andromedæ	0 21 47	+43 43·8
86·71	− 7·49	5·8	...		Cassiopeiæ	0 18 37	+52 22·9
86·96	+24·31	5·0	...		Cephei	22 55 18	+83 42·2
87·37	+ 1·27	5·4	...	12	Cassiopeiæ	0 18 11	+61 9·9
87·56	+ 3·58	...	...		B „ Nova 1572	0 18 9	+63 28·9
87·80	− 6·08	4·8	...	14	λ „	0 25 9	+53 51·6
88·17	−16·14	5·4	...		Andromedæ	0 30 15	+43 49·6
88·39	+ 2·31	4·2	...	15	κ Cassiopeiæ	0 26 11	+62 16·2
88·47	− 6·46	5·0	...		„	0 29 28	+53 30·4
88·54	− 6·74	3·7	...	17	ζ „	0 30 17	+53 14·2
88·69	− 0·31	5·6	...		„	0 29 39	+59 39·9
88·72	−11·29	5·6	...		„	0 32 22	+48 41·7
88·88	−21·29	5·6	...	32	Andromedæ	0 34 37	+38 48·0
89·12	− 4·12	var. 2·2	− 2·8	18	α Cassiopeiæ	0 33 42	+55 52·7
89·24	−10·14	4·8	...	19	ξ „	0 35 23	+49 51·2
89·24	−19·38	neb.	... Mess.	31	Andromedæ	0 36 9	+40 36·6
89·44	−13·62	5·0	...	20	π Cassiopeiæ	0 36 50	+46 22·1
89·48	+ 5·49	5·9	...		„	0 34 55	+65 29·3
89·61	−12·79	5·5	...		„	0 37 47	+47 12 6
89·66	−12·37	4·6	...	22	*o* „	0 38 3	+47 37·6
89·78	− 5·43	5·4	...		„	0 38 27	+54 33·9
89·84	+14·21	5·6	...	21	„	0 37 45	+74 19·9
89·91	−15·80	5·9	...		Andromedæ	0 39 32	+44 12·3
88·98	+14·19	5·3	...	23	Cassiopeiæ	0 39 47	+74 11·5
90·12	+23·06	5·5	...		Cephei	0 43 45	+83 3·3
90·23	+28·69	2·2	...		α Urs. min., Polaris	1 14 45	+88 40·1
90·25	− 2·82	3·6	... *d*	24	η Cassiopeiæ	0 41 51	+57 10·7
90·27	+25·62	4·5	...	43	Hev. Ceph., 2 Urs. min.	0 52 36	+85 36·7
90·33	− 9·69	5·0	...	25	ν Cassiopeiæ	0 42 2	+50 18·8
90·39	+ 3·60	5·4	...		„	0 43 27	+63 35·6
90·65	−19·56	4·4	...	35	ν Andromedæ	0 43 12	+40 25·5
90·67	−15·65	5·9	...		„	0 43 36	+44 20·9
90·73	+ 0·47	4·9	...		Cassiopeiæ	0 45 55	+60 27·9
91·03	− 1·66	5·1	...	26	v_1 „	0 47 53	+58 19·4

Galactic Long.	Lat.	Magn. H.P.	U.A.		Star.	α 1880. h m s	δ ° ′
°	°	m	m				
91·10	+19·08	5·6	...		Cephei	1 1 57	+79 2·1
91·13	+ 5·73	6·0	...		Cassiopeiæ	0 50 56	+65 42·2
91·18	+ 0·08	2·3	...	27	γ „	0 49 29	+60 4·0
91·20	− 0·26	5·5	...		„	0 49 34	+59 42·8
91·24	− 1·44	4·9	...	28	v_2 „	0 49 32	+58 32·0
91·80	+18·21	5·9	...		Cephei	1 13 16	+78 5·8
92·05	+ 1·00	5·9	...		Cassiopeiæ	0 56 55	+60 56·2
92·12	+ 8·23	5·3	...	31	„	1 2 33	+68 8·4
92·15	−22·11	3·9	...	37	μ Andromedæ	0 50 6	+37 50·9
92·43	+12·12	var. 6·7	−?		S Cassiopeiæ	1 10 51	+71 58·7
92·48	−15·87	5·7	... *d*		Andromedæ	0 53 16	+44 4·0
92·59	+ 4·50	5·5	...	32	Cassiopeiæ	1 3 53	+64 22·8
92·64	+ 3·68	5·4	...		„	1 3 41	+63 33·8
92·84	− 2·27	5·7	...		„	1 1 13	+57 37·3
92·97	− 5·56	5·2	...	30	μ „	1 0 18	+54 19·9
93·18	+21·17	6·0	...		Cephei	1 54 44	+80 43·2
93·24	−19·20	5·9	...	39	Andromedæ	0 56 10	+40 42·0
93·46	− 5·32	4·4	...	33	θ Cassiopeiæ	1 3 48	+54 30·7
93·60	+ 7·75	4·8	...	36	ψ „	1 17 28	+67 30·2
93·72	+ 9·94	5·9	...	38	„	1 22 19	+69 38·8
93·76	+12·78	5·5	...	40	„	1 28 57	+72 25·7
93·97	−13·23	4·3	...	42	φ Andromedæ	1 2 32	+46 36·1
94·01	−16·54	5·3	...	41	„	1 1 8	+43 18·1
94·33	+17·30	5·4	...	47	Cassiopeiæ	1 53 9	+76 42·2
94·35	− 2·13	5·2	...	34	φ „	1 12 33	+57 36·0
94·41	+ 5·83	5·9	...		„	1 22 30	+65 28·6
94·52	+21·89	5·9	...		Cephei	2 30 36	+80 55·9
94·62	+10·49	5·1	...	42	Cassiopeiæ	1 33 39	+70 0·9
94·64	−18·35	5·7	...	44	Andromedæ	1 3 30	+41 26·6
94·74	+16·20	5·3	...	49	Cassiopeiæ	1 54 5	+75 32·2
94·79	− 0·04	2·8	...	37	δ „	1 17 59	+59 36·6
95·14	+ 7·96	5·5	...	43	„	1 33 28	+67 26·1
95·19	−24·79	2·2	...	43	β Andromedæ	1 3 1	+34 59·0
95·28	−22·67	5·8	...	45	„	1 4 25	+37 5·1
95·76	+12·64	4·1	...	50	Cassiopeiæ	1 53 13	+71 50·4
95·97	− 0·86	4·9	...	39	χ „	1 26 6	+58 36·9
96·10	+11·16	4·6	...	48	A „	1 52 7	+70 19·4
96·22	+ 8·88	5·1	...	46	ω „	1 46 42	+68 5·7
96·33	+20·53	5·6	...	47	Hev. Cephei	2 50 12	+78 56·5

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h	m	s	δ 1880. °	′	″
96·45	−14·67	4·9	...	46 ξ Andromedæ	1	15	17	+44	54	0
96·75	− 2·00	5·8	...	Cassiopeiæ	1	30	18	+57	21	9
96·86	+ 0·66	5·5	...	44 „	1	35	13	+59	56	7
97·38	+ 4·00	3·6	...	45 ε „	1	45	46	+63	4	7
97·41	−14·65	4·8	...	48 ω Andromedæ	1	20	29	+44	47	2
97·46	−13·02	5·2	...	49 A „	1	22	55	+46	23	3
97·68	+ 5·07	5·2	...	Cassiopeiæ	1	50	48	+64	2	2
97·72	+23·27	5·2	...	49 Hev. Cephei	3	50	2	+80	21	9
97·93	−22·35	5·5	...	47 Andromedæ	1	16	49	+37	5	6
97·93	+ 5·44	5·7	...	52 Cassiopeiæ	1	53	57	+64	19	3
97·94	+19·52	5·5	...	48 Hev. Cephei	3	5	9	+77	17	5
98·08	+13·94	5·3	...	Cassiopeiæ	2	26	39	+72	17	5
98·09	+ 4·95	5·5	...	53 „	1	54	8	+63	48	6
98·57	+ 7·35	6·1	...	55 „	2	5	5	+65	57	6
98·59	−11·16	3·7	...	υ Persei, 51 Andr.	1	30	38	+48	1	2
99·06	− 8·95	4·2	...	φ Persei, 54 Andr.	1	36	9	+50	5	0
99·24	− 4·33	5·5	...	1 Persei	1	44	7	+54	33	1
99·46	+16·47	4·7	...	37 Hev. Cassiopeiæ	2	58	58	+73	56	1
99·60	+ 8·68	4·6	...	ι „	2	19	12	+66	51	7
99·72	−15·27	5·1	...	52 χ Andromedæ	1	32	9	+43	46	5
99·89	−18·26	4·2	...	50 υ „	1	29	45	+40	48	3
100·20	−16·28	5·6	...	„	1	33	28	+42	41	4
100·36	− 8·53	5·4	...	2 Persei	1	44	32	+50	11	9
100·54	−16·90	5·2	...	Andromedæ	1	34	29	+42	0	7
100·63	−11·46	6·0	...	Persei	1	41	49	+47	17	9
100·80	−18·94	4·9	...	53 τ Andromedæ	1	33	30	+39	58	1
100·81	+ 9·68	5·9	...	Cassiopeiæ	2	34	31	+67	18	8
100·85	− 4·56	4·9	...	4 *g* Persei	1	54	19	+53	54	4
101·76	− 9·80	5·7	...	3 „	1	50	46	+48	37	0
101·86	− 0·64	6·0	...	8 „	2	9	31	+57	20	5
102·26	− 1·31	cum.	...	*h* „	6m·8	2	10	39	+56	34	8
102·58	− 1·08	cum.	...	χ „	6m·7	2	13	27	+56	41	5
103·13	− 2·36	5·2	...	9 *i* „		2	14	0	+55	17	7
103·23	−18·21	5·6	...	55 Andromedæ		1	46	6	+40	8	2
103·53	− 7·29	5·4	...	6 Persei		2	5	38	+50	30	4
103·72	+15·72	4·6	...	5 Hev. Camelop.		3	37	43	+70	57	6
103·96	+15·31	5·3	...	„		3	36	46	+70	29	8
104·65	+ 7·45	5·8	...	Cassiopeiæ		2	57	17	+63	35	4
104·75	−16·12	2·1	... *d*	51 γ Andromedæ		1	56	32	+41	45	2

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ 1880. ° ′
		m	m				
104°76	+ 4°60	5·6	...		Cassiopeiæ	2 46 27	+61 1·8
...	...	5·8	...		Andromedæ	1 48 49	+36 41·3
104·81	−21·40	5·7	...	56	„	1 49 2	+36 39·7
104·95	+ 9·51	4·8	...	1 Hev.	Camelop.	3 9 27	+65 12·7
104·97	− 7·75	5·6	...	63	Andromedæ	2 13 2	+49 36·0
105·28	+18·94	6·0	...		Camelop.	4 19 37	+72 16·0
105·54	− 7·69	5·5	...	64	Andromedæ	2 16 27	+49 27·7
105·62	− 7·37	4 9	...	65	„	2 17 38	+49 44·1
105·70	−10·44	5·2	...	62 *c*	„	2 11 32	+46 49·5
105·75	+22·04	5·5	...		Camelop.	4 57 15	+73 47·3
105·79	−13·77	5·1	...	60 *b*	Andromedæ	2 5 42	+43 40·3
105·97	+ 8 91	5·6	...		Camelop.	3 14 16	+64 9·3
106·12	− 1·89	5·6	...	11	Persei	2 34 28	+54 35·6
106·15	+12·30	5·8	...		Camelop.	3 34 40	+66 49·4
106·60	+14·65	6·1	...		„	3 54 1	+68 20·7
106·74	− 0·70	3·9	...	15 *η*	Persei	2 41 57	+55 23·8
106·79	− 3·32	6·1	...		„	2 34 33	+53 0·8
107·10	−20·07	4·8	...	58	Andromedæ	2 1 15	+37 17·3
107·16	−18·80	5·6	...	59	„	2 3 36	+38 28·3
107·52	+11·23	4·6	...	7 Hev.	Camelop.	3 38 33	+65 9·2
108·17	+ 0·99	5 0	...	*k*	Persei	2 56 32	+56 14·0
108·34	−22·71	3·1	...	4 *β*	Trianguli	2 2 24	+24 25·1
108·36	+ 8·93	5·2	...		Camelop.	3 31 45	+62 49·5
108·53	−15·79	6·0	...	47 Hev.	Andromedæ	2 15 22	+40 51·0
108·62	+ 9·30	5·0	...		Camelop.	3 35 33	+62 57·8
108·64	− 3·25	4 0	...	18 *τ*	Persei	2 45 45	+52 16·2
108·80	− 7·12	4·2	...	13 *θ*	„	2 36 1	+48 43·2
109·05	+ 5·37	4 2	...	2 Hev.	Camelop.	3 19 22	+59 31 2
109·15	+ 2·08	5·9	...		Persei	2 6 37	+56 41·5
109·68	− 1·84	3·1	...	23 *γ*	„	2 56 7	+53 2·1
109·73	− 3·13	5·1	... *d*		„	2 52 19	+51 52·4
109·75	+ 4·56	4·8	...	3 Hev.	Camelop.	3 20 20	+58 27·7
109·80	+ 9·92	4·8	...		„	3 46 51	+62 43·1
110·17	−22·89	5·0	...	8 *δ*	Trianguli	2 9 44	+33 40·3
110·22	+13·16	5·5	...		Camelop.	4 9 24	+64 50·7
110·41	−23·21	4·2	...	9 *γ*	Trianguli	2 10 11	+33 17·5
110·42	+ 6·40	5·9	...		Camelop.	3 32 50	+59 34·8
110·98	− 11·57	5·6	...	14	Persei	2 36 17	+43 47·1

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
111·03	− 8·69	5·8	...		Persei	2	43	40	+ 46	20	7
111·07	+ 8·41	5·1	...		Camelop.	3	46	55	+ 60	45	3
111·21	+ 10·17	cum.		VII.	47 ,,	6m·5	3	57	16 + 62	0	3
111·31	− 13·10	cum.		Mess.	34 Persei	8m·0	2	34	15 + 42	16	6
111·49	− 13·22				,,	7m·2	2	34	53 + 42	4	6
111·56	+ 16·55	4·4	...		9 Camelop.		4	42	8 + 66	8	2
111·62	− 8·04	5·8	...		Persei		2	48	27 + 46	39	6
111·73	+ 1·71	5·0	...		4 Hev. Camelop.		3	20	52 + 55	2	1
112·05	+ 13·82	6·0	...		,,		4	25	10 + 64	0	5
112·08	− 7·71	5·6	...		Persei		2	51	42 + 46	44	3
112·17	− 4·89	4·1	...		,,		3	0	25 + 49	9	2
112·32	+ 10·56	5·6	...		Camelop.		4	6	20 + 61	32	8
112·43	+ 1·67	5·7	...		,,		3	24	31 + 54	34	0
112·44	− 19·91	5·3	...		14 Trianguli		2	24	47 + 35	36	8
112·50	− 3·14	5·2	...		Persei		3	7	38 + 50	29	5
112·52	− 15·39	4·9	...		12 ,,		2	34	41 + 39	41	1
112·60	− 18·55	6·0	...		,,		2	28	15 + 36	47	2
112·78	+ 5·72	5·8	...		Camelop.		3	43	59 + 57	37	1
113·07	+ 7·55	4·9	...		,,		3	54	28 + 58	49	2
113·21	− 3·54	5·3	...		29 Persei		3	10	5 + 49	46	8
113·34	− 3·60	5·0	...		31 ,,		3	10	36 + 49	39	3
113·54	+ 10·19	5·7	...		Camelop.		4	11	22 + 60	26	9
113·77	+ 14·68	5·9	...		,,		4	40	52 + 63	17	9
113·82	− 20·92	5·6	...		15 Trianguli		2	28	30 + 34	9	8
114·17	− 3·35	1·9	...		33 α Persei		3	15	46 + 49	25	9
114·38	− 3·98	5·2	...		Persei		3	14	43 + 48	46	9
114·46	+ 9·52	6·0	...		Camelop.		4	12	43 + 59	19	8
114·73	− 8·91	4·0	...		27 κ Persei		3	1	24 + 44	24	1
114·81	− 3·81	5·9	...		,,		3	17	27 + 48	41	7
114·84	+ 20·40	5·8	...		Camelop.		5	30	25 + 65	37	8
114·87	− 16·36	4·4	...		16 Persei		2	43	1 + 37	49	4
115·04	− 3·17	4·8	...		34 ,,		3	20	48 + 49	5	5
115·12	− 3·66	5·0	...		,,		3	19	32 + 48	38	6
115·18	+ 7·74	5·9	...		Camelop.		4	7	13 + 57	33	5
115·45	− 16·03	5·4	...		20 Persei		2	46	8 + 37	50	8
115·67	− 14·39	4·7	...		22 π ,,		2	51	5 + 39	10	9
116·08	− 4·30	4·4	...		35 σ ,,		3	22	7 + 47	34	8
116·40	+ 16·82	5·8	...		Camelop.		5	9	11 + 62	31	4

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ °	′	″
		m	m								
116°46	− 8°83	5·4	...	30	Persei	3	9	43	+43	35	0
116·58	−12·36	var. 2·3	− 3·5	26 β	„ , Algol	3	0	22	+40	29	5
116·60	+ 7·23	5·9	...		Camelop.	4	12	6	+56	12	9
116·63	+17·99	5·8	...	17	„	5	18	50	+62	57	9
116·70	−19·12	4·8	...	17	Persei	2	44	7	+34	33	9
116·71	−15·59	5·9	...		„	2	52	36	+37	39	2
116·74	− 0·36	5·7	...		„	3	39	28	+50	21	8
116·77	− 3·56	4·2	...	37 ψ	„	3	27	58	−47	47	5
117·13	+13·91	4·2	...	10	Camelop.	4	52	45	+60	15	9
117·20	−14·48	var. 3·4	− 4·2	25 ρ	Persei	2	57	29	+38	22	4
117·41	− 9·05	4·8	...	32 *l*	„	3	13	24	+42	53	7
117·47	− 5·70	5·4	....	36	„	3	24	8	+45	38	3
117·78	+ 0·43	5·5	...	43 A	„	3	47	41	+50	20	8
117·83	−13·20	4·7	...	28 ω	„	3	3	33	+39	9	3
117·87	− 3·23	3·2	...	39 δ	„	3	34	23	+47	24	1
117·87	−10·61	4·1	...	46 ξ	„	3	51	11	+35	26	7
118·05	−18·24	5·0	...	24	„	2	51	38	+34	42	1
118·12	+ 4·66	5·2	...	12 Hev.	Camelop.	4	7	22	+53	18	5
118·20	− 6·65	6·0	...		Persei	3	24	25	+44	26	7
118·53	+13·36	5·9	...	12	Camelop.	4	55	46	+58	51	1
118·56	+13·33	5·1	...	11	„	4	55	43	+58	48	2
118·85	+10·07	5·4	...	4	„	4	38	1	+56	32	5
119·22	+ 1·21	4·5	...	47 λ	Persei	3	57	39	+50	1	4
119·46	−21·24	5·2	...	21	„	2	50	1	+31	27	0
119·50	+ 6·48	5·5	... *d*	1	Camelop.	4	22	32	+53	38	9
119·53	− 1·80	5·4	...		Persei	3	47	20	+47	31	0
119·58	− 4·58	5·6	...		„	3	37	36	+45	18	2
120·39	+ 3·11	5·4	...		„	4	11	6	+50	37	6
120·59	− 4·68	5·9	...		„	3	41	43	+44	36	0
120·61	+ 2·44	4·6	...	*h*	„	4	9	13	+49	59	9
120·62	+ 7·06	5·5	...	2	Camelop.	4	30	28	+53	14	1
120·66	+ 9·89	5·8	...	5	„	4	45	15	+55	3	5
120·89	+ 2·38	5·6	...		Persei	4	10	13	+49	45	2
120·91	+ 6·79	5·4	...		Camelop.	4	30	28	+52	50	3
120·95	+ 2·72	7·2	var.?		Persei	4	11	56	+49	57	8
121·05	+19·13	5·2	...	31	Camelop.	5	44	13	+59	51	5
121·10	+14·41	5·3	...	16	„	5	13	11	+57	25	5
121·10	− 5·57	6·0	...		Persei	3	40	52	+43	35	5

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ 1880. ° ′
°	°	m	m				
121·23	− 0·51	4·3	...	48 *c*	Persei	3 59 57	+47 23·4
121·29	− 10·55	5·8	...		,,	3 25 41	+39 29·6
121·40	− 7·10	4·0	...	41 *ν*	,,	3 37 3	+42 11·9
121·52	+ 0·70	4·2	...	51 *μ*	,,	4 6 5	+48 6·2
122·06	+ 21·54	5·5	...	40	Camelop.	6 4 54	+60 1·8
122·07	+ 9·21	4·5	...	7	,,	4 47 40	+53 33·3
122·18	− 16·90	4·8	...	23 Hev.	Persei	3 11 14	+33 46·9
122·66	+ 8·53	5·9	...		Camelop.	4 46 37	+52 40·3
122·82	+ 20·46	5·3	...	37	,,	5 59 24	+58 56·9
123·25	+ 21·64	4·3	...	2	Lyncis	6 9 2	+59 3·1
123·61	− 16·78	5·6	...		Persei	3 17 0	+33 6·5
123·61	+ 5·14	5·7	...		,,	4 34 15	+49 44·5
123·66	+ 0·12	4·9	...	53 *d*	,,	4 12 53	+46 12·6
123·73	− 20·33	5·5	...		,,	3 8 2	+30 6·5
123·84	− 14·23	5·7	...		,,	3 25 2	+35 3·1
123·91	− 11·51	5·9	...		,,	3 33 20	+37 11·5
123·99	+ 11·50	var. 6·5 − ?			R Aurigæ	5 7 38	+53 26·9
124·03	+ 16·40	6·0	...		,, , 26 Camelop.	5 36 24	+56 3·8
124·12	− 16·09	5·5	...		Persei	3 20 49	+33 23·4
124·66	+ 3·80	5·7	...		,,	4 32 27	+48 3·9
124·67	+ 9·03	4·9	...	9	Aurigæ	4 57 17	+51 26·2
124·83	+ 14·34	6·0	...		,,	5 26 44	+54 20·8
124·89	− 7·56	3·0	...	45 *ε*	Persei	3 49 48	+39 39·7
124·98	+ 17·24	5·0	...	30 *ξ*	Aurigæ	5 44 47	+55 40·6
125·16	− 11·97	5·6	...		Persei	3 36 46	+36 4·8
125·38	+ 5·31	5·8	...		Aurigæ	4 42 8	+48 31 9
126·42	− 14·19	5·0	...	40 *o*	Persei	3 34 46	+33 34·7
126·63	+ 17·20	3·8	...	33 *δ*	Aurigæ	5 49 39	+54 16·4
127·00	− 5·03	4·9	...	52 *f*	Persei	4 6 43	+40 10·7
127·59	− 0·76	6·0	...	57 *m*	,,	4 24 58	+42 48·3
127·72	− 12·63	5·7	...		,,	3 44 14	+33 59·7
127·79	− 7·64	5·7	...	50	,,	4 0 37	+37 43·4
127·83	− 15·24	4·0	...	38 *o*	,,	3 36 48	+31 54·4
127·96	− 11·47	5·5	...		,,	3 48 45	+34 43·7
128·18	− 13·91	5·2	...	42 *n*	,,	3 41 58	+32 43·3
128·53	+ 0·72	5·3	...	59	,,	4 34 24	+43 8·1
128·82	+ 6·79	5·6	...		Aurigæ	5 1 47	+46 48·7
128·86	+ 19·83	5·5	...	45	,,	6 12 1	+53 30·6

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h	α m	α s	δ 1880. °	δ ′
°	°	m	m								
129·32	− 1·54	4·4	...	58	*e*	Persei	4	28	23	+ 41	1·0
129·40	+ 2·81	6·1	...			Aurigæ	4	46	15	+ 43	51·8
129·66	+ 13·24	5·4	...	27	*o*	„	5	36	36	+ 49	46·3
129·75	− 14·20	3·1	...	44	ζ	Persei	3	46	35	+ 31	31·6
130·21	+ 7·05	0·2	...	13	α	Aurigæ, Capella	5	7	49	+ 45	52·4
130·30	+ 1·59	5·5	...			„	4	44	19	+ 42	22·9
130·33	+ 10·79	6·1	...			„	5	27	12	+ 47	38·0
130·39	+ 3·67	var.	3·0 − 4·5	7	ε	„	4	53	22	+ 43	38·6
130·65	+ 15·18	6·0	...			„	5	50	3	+ 49	54·6
130·94	+ 15·67	6·0	...			„	5	53	29	+ 49	54·1
131·24	− 10·55	6·0	...			Persei	4	3	17	+ 33	16·3
131·96	− 8·48	5·1	...	54		„	4	12	37	+ 34	16·5
132·61	+ 2·04	4·0	...	8	ζ	Aurigæ	4	54	5	+ 40	53·9
132·63	+ 14·47	5·5	...	36		„	5	51	52	+ 47	53·5
132·72	+ 16·41	5·6	... *d*	41		„	6	2	25	+ 48	44·0
132·87	− 8·19	5·6	...	55		Persei	4	16	42	+ 33	51·1
132·95	+ 2·73	3·3	...	10	η	Aurigæ	4	58	6	+ 41	4·2
133·01	+ 5·41	6·0	...			„	5	9	42	+ 42	39·6
133·01	− 8·29	5·7	...	56		Persei	4	16	51	+ 33	40·9
133·13	+ 18·63	5·0	...	46	ψ	Aurigæ	6	15	39	+ 49	20·8
133·31	− 21·08	4·4	...	19	*q*	Tauri	3	38	4	+ 24	5·4
133·45	− 19·48	5·5	...			„	3	43	6	+ 25	12·9
133·49	− 21·06	4·0	...	20		„	3	38	41	+ 23	59·5
133·50	− 21·39	3·8	...	17		„	3	37	45	+ 23	44·1
133·85	− 2·12	5·2	...	1		Aurigæ	4	41	50	+ 37	16·5
133·87	− 14·45	5·2	...	42	ψ	Tauri	3	59	35	+ 28	40·5
133·88	− 21·30	4·2	...	23		„	3	39	12	+ 23	34·4
133·98	− 21·02	3·0	...	25	η	„	3	40	21	+ 23	44·0
134·19	+ 5·37	5·1	...	20	ρ	Aurigæ	5	13	19	+ 41	41·0
134·33	− 20·79	3·8	...	27		Tauri	3	42	2	+ 23	41·1
134·33	+ 15·38	4·5	...	35	π	Aurigæ	5	51	2	+ 45	55·4
134·62	+ 4·72	5·3	...			„	5	11	49	+ 40	57·6
134·71	− 0·43	5·1	...	4		„	4	51	7	+ 37	42·4
134·80	− 15·52	5·4	...	41		Tauri	3	59	15	+ 27	16·5
134·80	− 2·21	5·0	...	2		Aurigæ	4	44	36	+ 36	29·9
134·95	+ 5·09	5·5	...			„	5	14	25	+ 40	54·6
135·07	− 9·81	5·4	...			Persei	4	18	28	+ 31	10·0
135·10	− 21·91	5·3	...	57		Aurigæ	6	38	31	+ 48	54·8

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h	m	s	δ 1880. °	′	″
		m	m									
135·19	+ 12·85	2·1	...	24	β	Aurigæ	5	50	44	+ 44	56	0
135·27	+ 3·97	5·0	...	15	λ	„	3	10	42	+ 39	59	4
135·95	+ 2·13	4·9	...	11	μ	„	5	5	13	+ 38	20	4
136·01	+ 18·38	6·0	...	47		„	6	21	5	+ 46	45	6
136·32	− 15·66	5·6	...	44	*p*	Tauri	4	3	31	+ 26	10	0
136·86	− 20·74	5·7	...	32		„	3	49	47	+ 22	7	9
136·97	− 18·38	5·6	...	36		„	3	57	11	+ 23	46	5
137·21	− 13·53	5·1	...	52	φ	„	4	12	58	+ 27	3	7
137·34	+ 12·46	6·2	...	38		Aurigæ	5	54	39	+ 42	54	8
137·52	− 5·37	6·0	...			„	4	41	33	+ 32	22	5
138·11	− 3·77	2·7	...	3	ι	„	4	49	11	+ 32	58	5
138·14	+ 3·28	5·2	...	21	σ	„	5	16	30	+ 37	16	3
138·19	− 10·14	5·6	...			Tauri	4	27	7	+ 28	42	5
138·39	− 6·13	5·7	...			Aurigæ	4	41	31	+ 31	13	6
138·53	− 19·77	4·5	...	37	A	Tauri	3	57	36	+ 21	45	2
138·85	− 14·36	5·5	...	59	χ	„	4	15	17	+ 25	20	7
139·05	+ 19·64	5·2	...	55		Aurigæ	6	34	21	+ 44	38	3
139·28	+ 8·29	4·6	...	29	τ	„	5	40	52	+ 39	8	3
139·47	− 9·26	5·9	...			Tauri	4	33	49	+ 28	22	8
139·47	+ 22·25	4·7	...			Aurigæ, 16 Lyncis	6	48	52	+ 45	15	0
139·54	+ 8·66	4·2	...	32	ν	„	5	43	10	+ 39	6	7
139·65	+ 0·11	5·9	...			„	5	8	23	+ 34	10	3
140·08	− 15·03	6·2	...	62		Tauri	4	16	46	+ 24	1	2
140·25	+ 19·89	5·4	...	56		Aurigæ	6	38	5	+ 43	41	7
140·39	+ 0·53	5·1	...	19		„	5	12	6	+ 33	49	9
140·43	+ 0·23	5·3	...			„	5	11	6	+ 33	37	1
140·63	− 0·13	5·0	...	16		„	5	10	18	+ 13	14	7
140·76	+ 18·22	5·2	...	50		„	6	30	46	+ 42	35	6
140·85	− 1·00	5·2	... *d*	14		„	5	7	36	+ 32	22	8
140·87	+ 2·12	5·3	...	24	φ	„	5	19	42	+ 34	22	5
141·09	+ 7·63	5·2	...	31	υ	„	5	42	51	+ 37	16	2
141·20	− 20·75	5·8	...	43		Tauri	4	2	11	+ 19	17	4
141·25	− 17·83	5·4	...	51		„	4	11	17	+ 21	17	1
141·30	− 17·48	5·4	...	56		„	4	12	30	+ 21	28	9
141·59	− 15·64	4·6	...	69	υ	„	4	19	8	+ 22	32	4
141·61	− 15·35	5·4	...	72		„	4	20	7	+ 22	43	5
141·61	+ 10·87	5·3	...	40		Aurigæ	5	58	19	+ 38	29	5
141·63	− 7·79	5·9	...			Tauri	4	45	17	+ 27	41	7

Galactic Long.	Galactic Lat.	Magn. H. P.	Magn. U.A.			Star.	α 1880. h	m	s	δ 1880. °	′	″
141·76	−17·94	5·5	...	53		Tauri	4	12	22	+20	51	0
141·83	−18·70	4·6	...	50	ω	„	4	10	14	+20	16	9
141·84	−16·15	4·6	...	65	κ	„	4	18	13	+22	1	1
141·92	−16·21	5·5	...	67		„	4	18	16	+21	55	4
142·06	+ 9·06	2·7	...	37	θ	Aurigæ	5	51	32	+37	12	1
142·31	+19·91	5·0	...	58		„	6	42	17	+41	55	2
142·56	−17·34	5·9	...			Tauri	4	16	28	+20	42	1
142·60	+19·31	5·3	...	cum VIII. 71,		Aurigæ	6	39	54	+41	25	8
142·79	−16·14	5·7	...			Tauri	4	20	53	+21	21	0
143·20	+17·09	5·1	...	52		Aurigæ	6	30	28	+40	0	2
143·25	− 0·31	5·9	...			„	5	16	54	+31	1	8
143·36	+ 1·70	5·0	...	25	χ	„	5	24	55	+32	6	1
143·65	−13·12	4·4	...	94	τ	Tauri	4	35	3	+22	43	5
143·67	+16·85	5·7	...	51		Aurigæ	6	30	21	+39	29	7
143·80	−19·39	5·9	...			Tauri	4	13	27	+18	27	2
143·85	− 4·76	6·0	...			„	5	2	13	+27	52	6
144·10	− 1·83	5·6	...			Aurigæ	5	13	35	+29	26	6
144·32	− 0·41	5·8	...			„	5	19	28	+30	6	1
144·64	− 8·63	5·7	...	98	*k*	Tauri	4	50	49	+24	51	8
144·72	+ 0·59	var.	5−?			Aurigæ, Nova 1892	5	24	17	+30	31	2
144·80	−17·64	3·7	...	74	ε	Tauri	4	21	37	+18	54	8
145·15	−14·94	5·8	...			„	4	31	11	+20	26	5
145·17	−19·74	4·0	...	61	δ	„	4	16	1	+17	15	6
145·29	−19·03	4·2	...	68		„	4	18	33	+17	39	1
145·44	−19·59	4·7	...	64		„	4	17	11	+17	9	9
145·46	− 9·37	6·0	...	99		„	4	50	32	+23	45	6
145·48	+ 1·80	5·6	...	26		Aurigæ	5	30	56	+30	25	2
145·53	− 1·47	1·9	...	112	β	Tauri	5	18	42	+28	30	3
145·86	−20·15	5·6	...	63		„	4	16	32	+16	30	2
146·18	−21·57	3·9	...	54	γ	„	4	12	58	+15	20	2
146·31	+22·72	5·2	...	63		Aurigæ	7	3	24	+39	30	9
146·66	− 7·32	5·5	...	103		Tauri	5	0	48	+24	6	3
146·75	−21·77	5·1	...	58		„	4	13	48	+14	48	4
147·04	−19·51	5·3	...	75		„	4	21	35	+16	5	4
147·29	−20·38	4·6	...	71		„	4	19	30	+15	20	7
147·33	+ 9·08	6·1	...			Aurigæ	6	4	29	+32	43	1
147·38	−19·74	3·9	...	77	θ_1	Tauri	4	21	43	+15	41	6
147·47	−19·79	3·6	...	78	θ_2	„	4	21	49	+15	35	9

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ 1880. ° ′
147·51	−22·58	5·7	...	57	*h* Tauri	4 13 12	+13 44·7
147·52	−19·23	4·9	...		,,	4 23 42	+15 55·9
147·83	−22·16	5·8	...	60	,,	4 15 18	+13 47·5
147·90	−19·66	5·6	...	80	,,	4 23 18	+15 22·4
147·94	−19·54	5·5	...	81	,,	4 23 48	+15 25·8
148·08	−20·90	4·9	...	73	π ,,	4 19 50	+14 26·5
148·12	−18·03	1·0	...	87	α ,,	4 29 2	+16 16·0
148·12	− 9·85	4·7	...	102	ι ,,	4 55 55	+21 25·0
148·62	−13·71	5·1	5·6	97	i ,,	4 44 21	+18 38·0
148·71	− 8·88	5·8	...	105	,,	5 0 45	+21 32·7
148·75	− 2·90	5·4	...	118	,,	5 21 53	+25 3·1
149·16	−19·48	4·8	5·1	86	ρ ,,	4 27 2	+14 35·4
149·14	−17·78	4·8	...	92	σ_2 ,,	4 32 25	+15 40·7
149·22	−17·88	5·1	...	91	σ_1 ,,	4 32 18	+15 33·7
149·45	− 0·52	4·9	...	125	,,	5 32 18	+25 49·7
149·55	−20·79	5·4	...	83	,,	4 23 52	+13 28·0
149·57	+12·71	6·0	...		Aurigæ	6 24 37	+32 32·3
149·63	+ 2·96	4·5	...	136	Tauri	5 45 47	+27 34·9
149·68	+23·77	5·3	...	65	Aurigæ	7 14 1	+36 59·1
149·74	− 9·67	5·4	...	106	*l* Tauri	5 0 42	+20 15·5
149·82	−21·56	5·2	5·5	79	*b* ,,	4 22 7	+12 46·8
149·94	− 6·52	5·2	...	109	n ,,	5 12 4	+21 58·4
150·07	+17·19	3·7	...	34	θ Geminorum	6 44 53	+34 6·3
150·46	− 2·36	5·4	...	121	Tauri	5 28 7	+23 57·5
150·47	+ 8·09	4·5	...	44	κ Aurigæ	6 7 44	+29 32·4
150·72	+19·94	5·7	...		,,	6 58 17	+34 39·3
150·90	−13·60	5·8	...		Tauri	4 50 26	+16 57·8
150·96	+11·07	5·2	...	48	Aurigæ	6 20 51	+30 33·9
151·05	+ 9·22	6·0	...		,,	6 13 32	+29 35·6
151·07	+16·04	5·7	...		Geminorum	6 41 52	+32 44·5
151·13	−10·80	5·1	...	104	*m* Tauri	5 0 21	+18 28·9
151·19	− 5·02	4·8	...	114	o ,,	5 20 26	+21 50·0
151·28	−19·99	6·1	...		Aurigæ	6 59 29	+34 11·6
151·59	+ 2·98	5·1	...	139	Tauri	5 50 33	+25 56·2
151·70	+ 0·52	5·1	...	132	,,	5 41 39	+24 31·6
151·79	−20·11	4·3	4·5	90	*c* ,,	4 31 27	+12 16·1
152·15	− 1·31	6·0	...		,,	5 36 2	+23 8·7
152·35	−19·94	5·3	...	93	,,	4 33 23	+11 57·6

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h m s	δ 1880. ° ′
°	°	m	m					
152·57	−16·28	5·4	...	4	o_1 Orionis		4 45 45	+14 3·0
152·92	+ 1·88	6·0	...		Tauri		5 49 35	+24 13·8
153·33	+12·27	5·5	...	53	Aurigæ		6 30 46	+29 5·1
153·37	−22·04	4·6	4·6	88	*d* Tauri		4 29 4	+ 9 54·9
153·41	−13·26	4·7	...	11	Orionis		4 57 43	+15 14·1
153·71	−19·08	5·6	...		,,		4 39 21	+11 29·1
153·77	−15·97	4·3	...	9	o_2 ,,		4 49 37	+13 19·4
153·88	+11·21	4·9	...	49	Aurigæ		6 27 39	+28 6·9
153·89	−11·49	5·3	...		Orionis		5 4 48	+15 53·7
153·93	−19·73	5·3	5·9		,,		4 37 47	+10 55·3
153·98	−12·14	4·8	...	15	,,		5 2 50	+15 26·6
153·98	+13·51	5·4	...	28	Geminorum		6 37 9	+29 5·4
154·11	+12·18	5·7	...	54	Aurigæ		6 31 59	+28 22·0
154·19	+ 4·33	cum.	...	Mess. 35	Gemin.		8m·2 6 1 38	+24 26·6
154·43	− 7·36	5·4	...	115	Tauri		5 20 10	+17 51·5
154·54	− 8·23	5·2	...	111	,,		5 17 25	+17 16·2
154·58	− 6·01	4·6	...	119	,,		5 25 11	+18 30·2
154·62	+ 2·78	4·3	...	1	Geminorum		5 56 50	+23 16·1
154·80	− 5·78	5·3	...	120	Tauri		5 26 30	+18 27·2
155·21	+20·90	5·9	...		Geminorum		7 10 24	+31 10·1
155·29	−17·52	5·2	...	6	*g* Orionis		4 48 8	+11 13·7
155·29	+19·25	4·6	...	46	τ Geminorum		7 3 30	+30 26·4
155·33	+23·39	4·2	...	62	ρ ,,		7 21 23	+32 1·3
155·42	+17·38	6·0	...		,,		6 55 52	+29 32·6
155·67	+24·53	1·6	...*d*	66	α ,,	, Castor	7 26 56	+32 9·0
155·87	− 6·86	5·5	...		Tauri		5 25 17	+16 58·1
156·00	− 0·70	4·6	...	54	χ_1 Orionis		5 47 17	+20 15·1
156·06	−18·98	6·0	6·3		,,		4 45 8	+ 9 46·2
156·10	− 1·32	6·1	...		,,		5 45 17	+19 50·1
156·26	− 8·41	5·5	...	116	Tauri		5 20 52	+15 46·3
156·26	− 0·47	var.	6·4−?		U Orionis		5 48 42	+20 9·2
156·39	−18·24	4·8	5·0	7	π_1 ,,		4 48 17	+ 9 57·5
156·51	− 0·87	5·8	...	57	,,		5 47 50	+19 43·5
156·52	− 5·90	5·4	...	122	Tauri		5 30 6	+16 57·9
156·53	+ 4·55	var.	3·2−4·2	7	η Geminorum		6 7 38	+22 32·4
156·67	+24·31	5·4	...		,,		7 27 31	+31 13·2
156·81	−19·83	4·4	4·7	2	π_2 Orionis		4 44 4	+ 8 41·6
157·17	− 3·55	3·0	...	123	ζ Tauri		5 30 28	+21 4·1

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ 1880. ° ′ ″
°	°	m	m				
157·28	+ 1·13	4·8	...	62	χ_2 Orionis	5 56 48	+ 20 8·4
157·29	− 3·42	5·5	...	130	Tauri	5 40 26	+ 17 40·9
157·41	+ 11·62	3·2	...	27	ϵ Geminorum	6 36 33	+ 25 14·9
157·46	+ 6·16	3·2	...	13	μ „	6 15 42	+ 22 34·4
157·50	− 5·33	4·9	...	126	Tauri	5 34 22	+ 16 28·2
157·61	+ 0·81	5·1	...	64	Orionis	5 56 21	+ 19 41·4
158·23	+ 2·47	5·4	5·9	21	„	5 12 56	+ 2 28·2
158·37	− 21·12	3·3	3·2	1	π_2 „	4 43 20	+ 6 45·0
158·41	− 8·03	5·7	...	35	„	5 27 5	+ 14 13·2
158·42	− 19·63	5·6	6·0		„	4 48 18	+ 7 35·0
158·47	− 13·30	5·6	5·9	18	„	5 9 24	+ 11 12·3
158·55	+ 2·59	5·6	6·3	68	„	6 4 55	+ 19 48·9
158·56	+ 17·89	5·5	...	47	Geminorum	7 3 56	+ 27 3·1
158·80	− 15·52	5·3	5·9	16	h Orionis	5 2 44	+ 9 40·4
159·02	+ 21·23	4·0	...	60	ι Geminorum	7 18 16	+ 28 2·1
159·04	+ 22·08	5·1	...	64	„	7 21 52	+ 28 21·8
159·28	+ 22·10	5·1	...	65	b „	7 22 21	+ 28 9·7
159·43	+ 2·86	5·1	5·7	71	Orionis	6 7 47	+ 19 11·7
159·50	+ 25·22	4·1	...	75	σ Geminorum	7 35 49	+ 29 10·3
159·73	− 16·56	5·4	5·9	14	i Orionis	5 1 21	+ 8 20·4
159·78	− 21·61	4·0	3·7	3	π_4 „	4 44 49	+ 5 23·9
160·01	− 5·22	5·7	...	131	Tauri	5 40 23	+ 14 26·5
160·16	+ 6·26	4·0	...	18	ν Geminorum	6 21 50	+ 20 17·2
160·18	+ 14·97	5·3	...	42	ω „	6 55 6	+ 24 23·1
160·57	+ 25·34	1·1	...	78	β „ , Pollux	7 38 58	+ 28 18·9
160·57	− 5·43	5·2	...	133	Tauri	5 40 55	+ 13 51·3
160·58	− 4·65	5·7	...	135	„	5 43 39	+ 14 16·2
160·86	+ 22·96	4·2	...	69	υ Geminorum	7 28 32	+ 27 9·6
160·94	− 4·33	5·6	6·0	137	Tauri	5 45 33	+ 14 8·4
161·28	+ 17·00	5·8	...	48	Geminorum	7 5 9	+ 24 19·7
161·29	+ 11·64	5·2	...	36	„	6 44 21	+ 21 54·1
161·50	+ 19·67	5·0	...	57	A „	7 16 9	+ 25 16·8
161·71	+ 0·75	5·0	5·5	69	f_1 Orionis	6 5 8	+ 16 9·4
161·76	− 13·75	5·8	6·1		„	5 15 12	+ 8 18·5
161·87	− 5·71	4·8	5·4	134	Tauri	5 42 49	− 12 36·2
161·95	+ 14·88	5·8	...	44	Geminorum	6 58 5	+ 22 48·9
162·04	− 9·97	5·5	...		Orionis	5 28 36	+ 10 9·5
162·11	+ 1·45	5·4	5·9	72	f_2 „	6 8 30	+ 16 10·7

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h m s	δ °
°	°	m	m					
162·11	+15·33	var.	6·6—?		R	Geminorum	7 0 8	+22 52·9
162·30	−10·16	3·5	3·5 *d*	39	λ	Orionis	5 28 32	+ 9 51·1
162·34	− 0·87	4·4	4·7	67	ν	,,	6 0 43	+14 46·9
162·63	−10·45	4·4	5·0	37	ϕ_1	,,	5 28 14	+ 9 24·4
162·75	+24·24	5·3	...	76	*c*	Geminorum	7 36 48	+26 4·1
162·93	− 3·69	5·7	6·2			Orionis	5 52 8	+12 47·7
162·95	−20·79	...	6·2 var.	23		,,	5 54 15	+ 3 26·2
163·08	−22·75	3·9	3·7	8	π_5	,,	4 48 0	+ 2 14·6
163·08	−10·13	4·4	4·5	40	ϕ_2	,,	5 30 19	+ 9 13·4
163·36	− 0·25	4·2	4·7	70	ξ	,,	6 5 7	+14 14·0
163·53	+18·80	6·1	...	58		Geminorum	7 16 15	+23 10·5
163·63	−16·99	5·9	6·1			Orionis	5 8 21	+ 5 0·9
163·73	+13·72	var.	3·7—4·5	43	ζ	Geminorum	6 56 59	+20 44·7
163·77	− 4·79	6·1	6·5			Orionis	5 50 7	+11 30·2
163·79	− 0·64	5·7	...			,,	6 4 40	+13 39·8
163·96	+ 1·13	6·0	...			,,	6 11 16	+14 25·5
163·96	+ 7·82	5·0	5·7	26		Geminorum	6 35 25	+17 45·7
164·03	−14·16	1·9	1·7	24	γ	Orionis	5 18 42	+ 6 14·4
164·05	+ 0·22	5·7	6·6			,,	6 8 16	+13 53·1
164·10	+17·69	3·6	...	55	δ	Geminorum	7 12 57	+22 12·1
164·18	+23·78	3·6	...	77	κ	,,	7 37 12	+24 41·1
164·20	− 7·92	5·8	6·2			Orionis	5 40 17	+ 9 28·6
164·32	− 7·07	5·7	6·2			,,	5 43 26	+ 9 50·0
164·37	−22·24	4·7	4·7	10		,,	4 52 20	+ 1 31·7
164·47	− 3·32	5·9	6·5			,,	5 56 43	+11 40·9
164·53	+ 6·24	2·0	...	24	γ	Geminorum	6 30 47	+16 30·0
164·74	−10·82	5·6	6·3			Orionis	5 31 31	+ 7 28·1
165·15	−13·19	4·3	4·8	32	A	,,	5 24 22	+ 5 51·3
165·25	− 0·29	5·4	...	73		,,	6 9 1	+12 35·2
165·41	+19·06	5·3	...	63		Geminorum	7 20 37	+21 41·3
165·45	−18·52	4·5	5·1	17	ρ	Orionis	5 7 1	+ 2 43·0
165·46	− 5·91	6·1	6·4			,,	5 49 52	+ 9 29·4
165·58	− 0·28	5·1	...	74	*k*	,,	6 9 42	+12 18·2
165·76	+17·41	5·0	...	56		Geminorum	7 14 52	+20 40·1
166·01	+ 4·28	5·6	...			,,	6 26 47	+14 14·7
166·09	− 4·58	4·3	4·7	61	μ	Orionis	5 55 47	+ 9 38·8
166·10	+ 8·70	5·4	...	33		Geminorum	6 42 55	+16 20·2
166·17	−16·14	5·0	5·2	23	*m*	Orionis	5 16 32	+ 3 25·7

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h m s	δ 1880. ° ′
166·46	+18·39	5·7	...	61		Geminorum	7 19 52	+20 29·7
166·87	−19·82	5·9	6·3			Orionis	5 5 34	+ 0 53·3
167·00	− 9·28	5·3	5·9	52		„	5 41 33	+ 6 24·6
167·10	− 7·27	var.	1·0−1·4?	58	α	„	5 48 41	+ 7 23·0
167·12	−15·53	4·7	5·0	30	ψ	„	5 20 33	+ 2 59·4
167·40	+10·85	5·9	...	41		Geminorum	6 53 22	+16 14·6
167·45	+ 0·94	cum.				Monocer.	7m·5 6 17 53	+11 19·1
167·73	+ 1·15						8 6 19 12	+11 11·5
167·54	−14·49	5·5	6·0	33	n_1	Orionis	5 24 57	+ 3 12·0
167·65	−13·71	5·3	5·8	38	n_2	„	5 27 58	+ 3 41·0
167·68	− 1·31	5·2	5·9	75	l	„	6 10 30	+ 9 59·1
167·87	−12·37	4·5	5·0	47	ω	„	5 32 51	+ 4 3·1
167·94	−16·63	4·6	5·4	25		„	5 18 31	+ 1 44·1
168·05	+ 6·04	4·6	5·2	30		Geminorum	6 37 13	+13 20·8
168·08	+ 2·62	4·9	...			Monocer.	6 25 7	+11 37·6
168·30	+10·94	5·9	...			Geminorum	6 55 26	+15 30·4
168·45	+ 6·07	3·4	...	31	ξ	„	6 38 33	+13 1·4
168·45	+12·52	5·6	...	45		„	7 1 29	+16 7·2
168·70	−15·56	5·6	6·4			Orionis	5 23 41	+ 1 41·6
168·80	+13·69	5·4	...	51		Geminorum	7 6 29	+16 21·7
168·99	+14·87	3·6	...	54	λ	„	7 11 12	+16 45·3
169·05	− 9·85	6·0	6·5			Orionis	5 43 52	+ 4 23·2
169·34	+ 8·29	4·8	... *d*	38	*e*	Geminorum	6 47 52	+13 19·7
169·43	− 0·35	6·0	6·6			Monocer.	6 17 28	+ 8 57·7
169·56	−18·44	4·6	5·1	22	o	Orionis	5 15 38	− 0 30·1
169·59	−20·33	6·0	6·5			„	5 9 14	− 1 32·9
169·60	−17·89	...	6·2			„	5 17 34	− 0 16·4
169·99	+18·05	5·6	...			Geminorum	7 24 53	+17 20·4
170·04	−21·75	6·0	6·3			Orionis	5 5 17	− 2 38·4
170·08	− 6·18	5·7	6·3	63		„	5 58 34	+ 5 25·5
170·19	+21·74	5·1	...	81	*g*	Geminorum	7 39 11	+18 48·1
170·28	+19·96	5·2	...	74	*f*	„	7 32 33	+17 56·8
170·34	−18·10	5·2	5·6	27	*p*	Orionis	5 18 23	− 1 0·5
170·55	+ 3·64	var.	4·9−5·4	15	S	Monocer.	6 34 22	+10 0·3
170·03	−13·02	5·3	5·3	51	*b*	Orionis	5 36 16	+ 1 24·9
170·83	−16·18	var.	2·2−2·7	34	δ	„	5 25 53	− 0 23·4
171·15	− 0·97	var.	5·8−8·2		T	Monocer.	6 18 44	+ 7 9·0
171·17	− 6·82	5·7	6·2	66		Orionis	5 58 38	+ 4 9·8

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
171·24	−17·07	var.	4·7−6	31	Orionis	5	23	38	− 1	11·3	
171·38	+17·89	5·0	...	68	Geminorum	7	26	46	+16	5·0	
171·59	−10·68	5·0	5·5	56	Orionis	5	46	13	+ 1	49·5	
171·73	−18·86	3·5	3·4	28 η	,,	5	18	27	− 2	30·5	
171·80	−16·29	...	6·1		,,	5	27	26	− 1	14·5	
171·88	+ 0·79	4·3	5·0	13	Monocer.	6	26	25	+ 7	25·2	
171·90	− 3·69	...	6·2 var.		Orionis	6	10	55	+ 5	8·1	
171·99	−23·80	2·9	2·8	67 β	Eridani	5	1	57	− 5	14·6	
172·08	−16·69	5·2	6·1		Orionis	5	26	37	− 1	40·8	
172·20	−15·73	1·8	1·8	46 ε	,,	5	30	7	− 1	16·8	
172·36	− 9·41	6·1	6·1	59	,,	5	52	10	+ 1	49·4	
172·39	+ 9·17	5·2	...		Geminorum	6	56	59	+11	7·6	
172·42	+ 7·14	5·7	...		Monocer.	6	49	50	+10	6·6	
172·44	+ 4·34	5·6	6·5	16	,,	6	40	0	+ 8	42·8	
172·73	−14·69	5·1	5·7		Orionis	5	34	45	− 1	11·6	
173·02	+ 4·25	5·0	5·3	17	Monocer.	6	40	49	+ 8	9·9	
173·12	− 6·79	5·5	5·8		Orionis	6	2	42	+ 2	31·0	
173·17	− 2·50	4·4	4·8 *d*	8	Monocer.	6	17	25	+ 4	39·1	
173·33	−18·32	6·0	6·5		Orionis	5	23	25	− 3	32·6	
173·38	+ 5·60	5·7	6·3		Monocer.	6	46	18	+ 8	31·5	
173·45	−15·12	1·9	1·8 *d*	50 ζ	Orionis	5	34	42	− 2	0·5	
173·47	+ 1·17	6·0	6·7		Monocer.	6	30	58	+ 6	14·1	
173·52	− 9·99	5·2	5·7	60	Orionis	5	52	39	+ 0	32·4	
173·78	−15·88	3·7	4·0	48 σ	,,	5	32	43	− 2	40·2	
173·84	− 0·61	...	cum.		Monocer.	7m	6	25	33 +	5	1·6
173·87	−18·99	5·9	...		Geminorum	7	35	17	+14	29·2	
173·96	+ 8·24	6·0	6·4		Monocer.	6	56	44	+ 9	18·7	
173·97	− 0·56	5·7	6·3 cum.	12	,,	6	25	57	+ 4	56·4	
174·20	+ 8·78	...	6·1		,,	6	59	5	+ 9	21·9	
174·25	+14·13	5·4	5·8	1	Canis min.	7	18	18	+11	54·2	
174·50	+15·33	5·0	5·0	6	,, ,,	7	23	7	+12	14·9	
174·75	−16·19	6·0	6·7		Orionis	5	33	32	− 3	38·0	
174·96	−22·55	3·6	3·9	20 τ	,,	5	11	47	− 6	58·5	
175·05	− 2·60	5·8	6·2		Monocer.	6	21	4	+ 2	58·7	
175·39	−17·71	4·6 5·0	5·5 6·1	42 *c*	Orionis	5	29	28	− 4	55·1	
175·69	−25·31	4·4	4·6	69 λ	Eridani	5	3	24	− 8	54·6	
175·85	−23·87	0·3	1·0	19 β	Orionis, Rigel	5	8	46	− 8	20·5	

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h m s	δ 1880. ° ′
175·88	− 18·01	4·4	5·0	41	θ_1 Orionis	5 29 23	− 5 28·2
...	...	4·9	5·2	43	θ_2 „	5 29 29	− 5 29·8
175·98	+ 8·42	6·0	6·1		Monocer.	7 1 20	+ 7 39·5
176·38	− 18·22	3·0	2·9	44	ι Orionis	5 29 34	− 5 59·4
176·38	− 14·48	5·7	6·5		„	5 42 37	− 4 7·8
176·41	− 18·35	4·5	5·5 var.		„	5 29 11	− 6 5·0
176·50	+ 13·16	5·0	5·6	2	ϵ Canis min.	7 19 5	+ 9 30·7
176·57	− 6·84	5·6	6·1		Orionis	6 9 28	− 0 28·1
176·68	− 21·63	4·3	4·4	29	e „	5 18 10	− 7 55·2
176·91	− 11·48	4·7	5·2		„	5 54 3	− 3 4·8
177·12	+ 13·54	4·6	5·1	4	γ Canis min.	7 21 38	+ 9 10·0
177·18	− 22·06	5·8	6·6		Orionis	5 17 33	− 8 31·8
177·22	− 19·66	4·7	5·1	36	ν „	5 26 8	− 7 23·5
177·31	− 3·91	5·2	5·9	77	„ , Monoc.	6 21 4	+ 0 22·2
177·52	+ 23·36	5·1	5·4	8	Cancri	7 58 23	+ 13 27·5
177·60	+ 18·35	5·5	5·6	11	Canis min	7 39 40	+ 11 3·6
177·68	+ 13·03	3·1	3·0	3	β „ „	7 20 39	+ 8 31·8
177·72	− 13·23	5·9	6·0		Orionis	5 49 34	− 4 38·3
177·82	− 4·19	...	6·1	78	„ , Monoc.	6 21 8	− 0 12·3
178·01	− 18·10	5·0	5·2	49	d „	5 33 5	− 7 16·9
178·02	+ 1·65	4·8	5·2	18	Monocer.	6 41 36	+ 2 32·5
178·08	+ 8·42	6·0	6·3		Canis min.	7 5 27	+ 5 51·1
178·13	− 17·03	6·0	6·4		Orionis	5 37 4	− 6 51·4
178·15	− 4·95	5·8	6·3		„ , Monoc.	6 19 8	− 0 52·4
178·16	+ 7·03	5·7	6·5		Monoc., Can. min.	7 0 44	+ 5 5·7
178·72	− 10·60	5·2	5·9		Orionis, Monoc.	6 0 42	− 4 11·0
178·84	− 0·80	5·7	6·3		Monocer.	6 34 55	+ 0 36·3
178·90	+ 12·57	5·3	5·9	5	η Canis min.	7 21 35	+ 7 11·1
178·94	− 6·12	var.	6·9 − ?		V Monocer.	6 16 41	− 2 8·2
179·16	− 3·69	5·0	5·7		„	6 27 32	− 1 7·8
179·26	− 7·08	5·1	5·5		„ , Orionis	6 13 59	− 2 53·7
179·83	− 15·53	5·3	5·9	55	Orionis	5 45 34	− 7 33·1
180·03	− 9·04	5·6	6·2		Monocer.	6 8 41	− 4 32·1

The second half of the list will be given in one of the next numbers of the *Monthly Notices*.

Colonel Cooper's Observatory:
Markree, Collooney, Ireland.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. JANUARY 13, 1893. No. 3

E. B. KNOBEL, Esq., President, in the Chair.

Joseph Ibbitson Berry, 20 Alwyne Road, Canonbury, N.;
Martin Brendel, Ph.D., Privat-Docent at the University, Greifswald, Germany;
Ernest Gould Dixon, 4 The Lawn, Balham Park Road, S.W.;
Harold Dennis Taylor, 20 Bootham Terrace, York,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Maurice Anderson Ainslie, B.A., Giggleswick School, Settle, Yorkshire (proposed by W. H. M. Christie);
James Arthur Formoy, F.C.S., Lestelle, London Road, Forest Hill, S.E. (proposed by Raphael Meldola);
Henry Bateman Massey, Engineer, &c., Spalding (proposed by George Calver);
John Mills, Editor of *Science and Art*, 11 Henrietta Street, Covent Garden, W.C., and 44 Orbel Street, Battersea Park, S.W. (proposed by A. Fowler);
Edward Turner Whitelow, Civil Engineer, 70 Deansgate, Manchester (proposed by Arthur Mee).

Seventy-six presents were announced as having been received since the last meeting, including, amongst others—

Arthur Cayley, Collected Mathematical Papers, vol. v., presented by the author; Sir R. S. Ball, Atlas of Astronomy,

presented by the publishers; Berlin Observatory, Zonenbeobachtungen 20° bis 25°, presented by the Observatory; Padua University, Papers relating to the Galileo Tercentenary, presented by the University; *Nautical Almanac* for 1896, and ditto, part i., presented by the Admiralty; Fifteen lantern slides of solar prominences, faculæ, &c., taken at the Kenwood Observatory, Chicago, presented by Professor G. E. Hale; Seven lantern slides of lunar eclipse, 1892, May 11, presented by Mr. Newbegin.

Opposition of Mars, 1892. *Observations made at the Royal Observatory, Cape of Good Hope.* By David Gill, LL.D., F.R.S., H.M. Astronomer.

When Professor Eastman's programme reached the Cape I removed the declination micrometer frame of the transit circle, and with the apparatus which is attached for this purpose to our Repsold photograph-measuring micrometer ruled a pair of lines upon it and inserted a new pair of webs, 16″ apart, parallel to the old declination web.

Subjoined are the data relative to the distance and inclination of the wires thus inserted.

The distance between the wires at the middle wire was found to be 16″·03.

The inclination was determined as follows:—

1. The transit circle pointing north was placed horizontal, and the north collimator was rotated about its optical axis till the horizontal web of the collimator became parallel to that of the transit circle.

2. The south collimator was directed upon the north collimator, and its horizontal wire adjusted to parallelism with that of the north collimator.

3. The transit circle was then directed to the south collimator, and the inclination of its horizontal wire with respect to the corresponding collimator wire was measured. It is clear that half the apparent inclination of the horizontal web of the transit circle to that of the south collimator will then be the true inclination of the transit-circle web.

The process is an exceedingly accurate one, independent determinations on June 23, 27, 29, and 30 giving practically identical results.

For the new wires (named Y and Z) the mean corrections were:—

At point of intersection by the vertical webs

	Middle Wire.					
	α	β	ι	γ	γ	δ
Y	−0″·06	−0″·01	+0″·02	+0″·02	−0″·04	+0″·06
Z	−0·02	+0·01	−0·02	+0·03	−0·01	+0·05

These are the actual means of observations, which should, of course, be smoothed to quantities proportional to the distance, if rigorous corrections were required for inclination. But the method of observation has been so arranged that the effect of inclination of the wires is entirely eliminated. In observing stars, the image was first bisected near wire α with wire Y and near wire 1 with Z; the reversing prism was then rotated 90° on its axis and the star again bisected with Z near wire 7 and with Y near wire δ; or Z might be used first to bisect near wire α, in which case it was also used to bisect near wire δ, while Y was used at wires 1 and 7. Thus, in every case, the prism was reversed between the observations at wires 1 and 7, and the star was bisected by both wires in each position of the prism.

The interval from α to 1, 1 to 7, 7 to δ is about twenty-six seconds, allowing ample time to read the declination micrometer.

In observing the image of *Mars*, the pointings up to August 4 (inclusive) were made in the manner requested by Professor Eastman by two similar pointings at α and 1, the prism then being rotated 90° (*i.e.* a visual rotation of the image of 180°) and two further similar pointings made at 7 and δ. From August 5 to September 21 the prism was rotated 90° in the same direction after each pointing, so that the image was presented to the observer under every possible variety of reversion. Corrections for refraction and curvature of the path, as well as those for division-error, screw-error, and runs, have been rigorously applied, but the corrections for parallax of the planet, and for reduction to the mean places of the stars, have been omitted, as they must in any case be recomputed on a rigorous and uniform basis by anyone who undertakes a discussion of the observations.

The zenith distances have been referred to the nadir.

The initials of the observers P. and C. are those of Messrs. R. T. Pett and W. H. Cox.

Royal Observatory, Cape of Good Hope:
1892 *December* 10.

Observations of Mars and Comparison Stars made at the Royal Observatory, Cape of Good Hope, 1892.

Date. 1892.	Obs.	*O. Arg. S.* 20970.	*η Capricorni.*	*27 Capricorni.*	*φ Capricorni.*	*Mars.*	*Lacaille* 8851.	*41 Capricorni.*	*D. M.* −20 6293.	*Lalande* 42700.
		112° 25′	110° 16′	110° 59′	111° 5′		113° 55′	113° 44′	110° 4′	111° 38′
June 28	P	...	48″·98	17″·34	52″·40	110° 21′ 21″·66	56″·44	55″·86	30″·27	51″·97
30	P	...	48″·11	17″·29	52″·28	110° 27′ 20″·59	56″·46	55″·86	29″·88	51″·79
July 1	C	4″·25	49″·21	17″·54	53″·13	110° 30′ 39″·93	56″·65	55″·59	29″·63	51″·75
6	P	3″·29	47″·61	16″·19	50″·99	110° 50′ 28″·00	54″·82	54″·15	28″·04	50″·37
7	C	3″·21	47″·89	16″·38	51″·68	110° 55′ 3″·00	56″·12	55″·24	28″·83	50″·58
8	P	3″·78	48″·30	17″·51	52″·12	110° 59′ 49″·98	56″·15	55″·40	29″·37	51″·21
11	C	5″·30	49″·06	17″·05	52″·80	111° 15′ 14″·54	55″·81	55″·14	29″·19	50″·68
19	C	3″·34	48″·05	16″·85	51″·78	112° 2′ 50″·02	55″·61	54″·74	28″·48	50″·72
20	P	3″·06	47″·22	15″·70	50″·73	112° 9′ 13′·39	54″·79	54″·20	27″·51	50″·04
22	P	2″·98	47″·89	16″·49	51″·94	112° 22′ 11″·12	55″·50	54″·95	28″·47	50″·36
26	P	2″·90	47″·27	15″·69	50″·84	112° 48′ 5″·98	54″·61	53″·82	27″·48	49″·59

Date. 1892.	Obs.	*Lacaille* 8463.	*Lacaille* 8506.	*17 Capricorni.*	*Lacaille* 8612.	*Mars.*	*Lacaille* 8813.	*Lacaille* 8832.	*Lacaille* 8851.	*O. Arg. S.* 21562.
		112° 44′	114° 36′	111° 54′	114° 11′		114° 17′	115° 39′	113° 55′	112° 24′
July 27	C	53″·07	10″·55	...	8″·71	112° 54′ 29″·20	...	...	...	...
28	P	52″·74	11″·55	16″·67	9″·03	113° 0′ 47″·79	4″·62	46″·75	53″·85	57″·36
30	P	52″·80	11″·09	16″·72	9″·42	113° 13′ 6″·69	4″·77	47″·28	55″·23	57″·26
Aug. 1	P	53″·33	11″·50	16″·97	8″·75	113° 24′ 52″·57	4″·41	46″·84	54″·89	56″·81
2	C	52″·77	11″·36	16″·94	9″·21	113° 30′ 31″·52	4″·62	47″·53	55″·35	57″·13
3	P	51″·82	10″·39	16″·58	9″·42	113° 35′ 59″·97	3″·96	46″·72	54″·23	58″·03
4	C	53″·18	12″·00	17″·59	9″·55	113° 41′ 15″·60	4″·99	47″·28	55″·62	57″·29
5	P	52″·48	11″·13	16″·91	9″·01	113° 46′ 18″·79	4″·93	47″·27	55″·07	57″·49
6	C	52″·27	11″·34	16″·39	...	113° 51′ 8″·71	...	...	...	...
10	C	53″·75	13″·31	18″·58	10″·06	114° 8′ 0″·88	5″·48	47″·93	55″·74	57″·59

Date. 1892.	Obs.	*O. Arg. S.* 20429.	*Lacaille* 8463.	*Lacaille* 8506.	17 *Capricorni.*	*Mars.*	*Lacaille* 8734.	*Lalande* 41404.	ζ *Capricorni.*	37 *Capricorni.*
		113° 49′	112° 44′	114° 36′	111° 54′		115° 17′	112° 50′	112° 52′	110° 33′
Aug. 11	P	...	52″·54	11″·17	16″·59	114° 11′ 32″·51	13″·33	28″·51	35″·29	46″·65
12	C	2″·07	53″·65	11″·69	17″·02	114° 14′ 47″·23	13″·26	28″·49	35″·50	46″·94
16	C	...	53″·11	...	17″·10	114° 24′ 48″·95	13″·05	28″·31	35″·30	45″·66
18	C	1″·95	53″·79	12″·08	17″·08	114° 27′ 57″·72	11″·43	...	...	...
19	P	1″·25	52″·38	11″·47	16″·66	114° 29′ 3″·17	13″·92	28″·92	35″·53	47″·20
20	C	1″·97	53″·12	12″·32	17″·84	114° 29′ 51″·35	13″·20	28″·34	33″·93	45″·85
22	C	2″·28	53″·69	12″·39	17″·48	114° 30′ 25″·31	13″·38	...	...	...
24	C	2″·62	54″·25	11″·87	17″·70	114° 29′ 43″·50	13″·69	28″·81	36″·20	46″·83
26	C	...	53″·66	...	17″·87	114° 27′ 44″·93	...	...	34″·91	...
29	P	2″·43	53″·97	12″·56	...	114° 22′ 27″·99	13″·82	29″·27	35″·92	46″·41
30	C	...	53″·38	...	17″·63	114° 20′ 6″·35	14″·00	29″·57	36″·20	47″·23
Sept. 1	C	1″·60	54″·10	12″·22	17″·42	114° 14′ 31″·42	14″·47	28″·47	35″·35	46″·43
2	P	2″·84	53″·87	12″·72	17″·81	114° 11′ 18″·07	13″·69	28″·77	35″·92	46″·58
3	C	3″·32	54″·47	13″·19	18″·13	114° 7′ 48″·58	14″·62	29″·34	35″·85	47″·05
6	P	3″·16	54″·25	13″·39	17″·94	113° 55′ 45″·26	14″·73	29″·62	36″·73	47″·36
7	C	2″·61	54″·69	12″·99	18″·61	113° 51′ 14″·02	15″·09	30″·13	36″·16	47″·78
8	P	2″·87	54″·96	13″·49	18″·30	113° 46′ 27″·57	...	...	....	...
12	P	3″·46	54″·72	13″·24	18″·46	113° 25′ 3″·43	15″·00	29″·92	16″·74	47″·76
13	C	3″·43	54″·75	13″·58	18″·76	113° 19′ 8″·98	15″·23	30″·07	36″·66	47″·77
14	P	3″·43	54″·67	13″·04	19″·07	113° 13′ 2″·09	...	...	36″·58	47″·00
15	C	...	54″·65	13″·55	18″·42	113° 6′ 41″·20	14″·74	30″·09	36″·96	47″·59
17	C	3″·82	55″·11	14″·15	18″·72	112° 53′ 24″·13	15″·39	30″·48	36″·73	...
19	C	3″·77	55″·19	13″·72	18″·92	112° 39′ 18″·81	14″·93	30″·90	37″·26	48″·17
20	P	4″·18	54″·99	13″·99	18″·82	112° 31′ 58″·48	15″·30	30″·73	36″·76	48″·15
21	C	4″·16	55″·51	14″·65	19″·27	112° 24′ 26″·85	16″·04	30″·78	37″·40	48″·76

On the Determination of the Equations for the Perturbation of the Inclination and Node of an Orbit by the Method of Variation of Constants. By Robert Bryant, D.Sc., B.A.

The method adopted by Oppolzer and by Watson for determining the differential equations for the change in the position of the plane of the orbit seems to me less simple than the following.

Taking the sun's centre as origin, let three rectangular axes be chosen, whose positions will be more closely specified hereafter.

Let

x, y, z be the coordinates of the disturbed planet,

and

x', y', z' " " disturbing "

Then k being the Gaussian constant and p the semi-parameter of the orbit, we have

$$k\sqrt{p(1+m)}\cos i = xv_y - yv_x$$
$$k\sqrt{p(1+m)}\sin \Omega \sin i = yv_z - zv_y$$
$$-k\sqrt{p(1+m)}\cos \Omega \sin i = zv_x - xv_z$$

where v_x, v_y, v_z, are the velocities of the disturbed planet parallel to the coordinate axes.

By the differentiation of these equations and the introduction of suitable modifications we obtain the required results.

Now the quantities on the right-hand sides of the above equations are subject to two distinct kinds of variation: one arising from a change in the time only, such as occurs in the case of undisturbed motion; the other, that arising from the perturbation. Denote the former of these by the symbol $\frac{d_1}{dt}$, and the latter by $\frac{d_2}{dt}$, and let $\frac{d}{dt}$ denote the total variation, so that

$$\frac{d}{dt} = \frac{d_1}{dt} + \frac{d_2}{dt}.$$

Then putting for brevity

$$P = k\sqrt{p(1+m)},$$

we have

$$\frac{dP}{dt}\cos i - P\sin i\frac{di}{dt} = \frac{dx}{dt}v_y + x\frac{dv_y}{dt} - \frac{dy}{dt}v_x - y\frac{dv_x}{dt}.$$

$$\frac{dP}{dt}\sin \Omega \sin i + P\cos \Omega \sin i\frac{d\Omega}{dt} + P\sin \Omega \cos i\frac{di}{dt} = \frac{dy}{dt}v_z + y\frac{dv_z}{dt} - \frac{dz}{dt}v_y - z\frac{dv_y}{dt}.$$

$$\frac{dP}{dt}\cos \Omega \sin i - P\sin \Omega \sin i\frac{d\Omega}{dt} + P\cos \Omega \cos i\frac{di}{dt} = \frac{dz}{dt}v_x + z\frac{dv_x}{dt} - \frac{dx}{dt}v_z - x\frac{dv_z}{dt}.$$

The total differentials

$$\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt}$$

are the velocities parallel to the coordinate axes.

Also

$$x\frac{dv_y}{dt} - y\frac{dv_x}{dt} = x\left(\frac{d_1v_y}{dt} + \frac{d_2y}{dt}\right) - y\left(\frac{d_1v_x}{dt} + \frac{d_2v_x}{dt}\right)$$

$$= x\frac{d_1v_y}{dt} - y\frac{d_1v_x}{dt} + x\frac{d_2v_y}{dt} - y\frac{d_2v_x}{dt}.$$

Now at any instant the body is supposed to be describing an undisturbed orbit, in which case the area swept out by the radius vector is proportional to the first power of the time only, and its rate of change is therefore constant, as is also the projection upon the coordinate planes.

But

$$x\frac{d_1v_y}{dx} - y\frac{d_1v_x}{dt},$$

is proportional to the second differential with respect to the time of this area projected on the plane of xy, and therefore vanishes, as also do the corresponding quantities for the planes of yz and zx.

Also

$$\frac{d_2}{dt}(\text{velocity in any direction}) = \text{acceleration in that direction due to perturbation.}$$

Hence if X, Y, Z be the perturbative accelerations parallel to the respective coordinate axes, our equations are simplified to

$$\frac{dP}{dt}\cos i - P\sin i\frac{di}{dt} = xY - yX$$

$$\frac{dP}{dt}\sin\Omega\sin i + P\cos\Omega\sin i\frac{d\Omega}{dt} + P\sin\Omega\cos i\frac{di}{dt} = yZ - zY$$

$$\frac{dP}{dt}\cos\Omega\sin i - P\sin\Omega\sin i\frac{d\Omega}{dt} + P\cos\Omega\cos i\frac{di}{dt} = xZ - zX.$$

From the last two equations we deduce

$$\frac{dP}{dt}\sin i + P\cos i\frac{di}{dt} = (yZ - zY)\sin\Omega + (xZ - zX)\cos\Omega,$$

whence by aid of the first equation

$$P\frac{di}{dt} = (yZ - zY)\sin\Omega\cos i + (xZ - zX)\cos\Omega\cos i - (xY - yX)\sin i.$$

Also

$$P\sin i\frac{d\Omega}{dt} = (yZ - zY)\cos\Omega - (xZ - zX)\sin\Omega.$$

Hitherto we have left the positions of the rectangular coordinate axes quite arbitrary, except that their point of intersection is at the Sun's centre. Our equations will be still further sim-

plified by a suitable choice of axes. First, let the axis of x be directed towards the ascending node of the instantaneous orbit upon the ecliptic.

Then

$$P\frac{di}{dt} = (xZ - zX)\cos i - (xY - yX)\sin i,$$

and

$$P\sin i\frac{d\Omega}{dt} = yZ - zY.$$

Next, if we adopt the plane of the instantaneous orbit as the plane of xy, we have still more simply

$$P\frac{di}{dt} = xZ.$$

$$P\left[\sin i\frac{d\Omega}{dt}\right] = yZ.$$

Sin $i\,d\Omega$ is the projection of the perturbation of the node upon a great circle perpendicular to the plane of the instantaneous orbit.

There now only remains to determine the disturbing acceleration Z; X and Y now no longer appearing in our equations.

The fundamental equations of notion referred to axes originating in the Sun's centre are

$$\frac{d^2z}{dt^2} + k^2(1+m)\frac{z}{r^3} = k^2\Sigma m'\left(\frac{z'-z}{\rho^3}\right) - \frac{z'}{r'^3},$$

ρ being the distance between the disturbing and disturbed planets with two similar equations for x and y.

We will consider only one disturbing planet, the results for several planets merely requiring to be added together.

Then

$$Z = k^2m'\frac{z'-z}{\rho^3} - \frac{z'}{r^3}.$$

But as we have adopted the instantaneous plane of the orbit as the plane of xy, we have

$$z = 0.$$

Also if u be the argument of latitude,

$$x = r\cos u,\ y = r\sin u,$$

and substituting for P its value

$$k\sqrt{p(1+m)},$$

we have finally

$$\frac{di}{dt} = \frac{Kkm'}{\sqrt{p(1+m)}}z'r\cos u,$$

$$\sin i\frac{d\Omega}{dt} = \frac{Kkm'}{\sqrt{p(1+m)}}z'r\sin u,$$

where

$$K = \frac{1}{\rho^3} - \frac{1}{r'^3}.$$

We might also have determined from the above equations the value of

$$\frac{dP}{dt},$$

and thence

$$\frac{dp}{dt},$$

and thus have found a relation between the variations of the major axis and the eccentricity. Thus our equations really determine the variations of three of the six elements of the orbit.

On the Variation of Latitude by the Greenwich Transit-Circle Observations. By S. C. Chandler.

The interesting communication of Messrs. Thackeray and Turner in the *Monthly Notices* for November 1892 was manifestly prepared before seeing the final law of the variation of latitude in No. 277 of the *Astronomical Journal*. I trust they will not deem it an encroachment on their province to point out that the general accordance of the observations with the provisional law of No. 267, which they have used, is still more satisfactory when the comparison is made with the definitive law. Without presuming to make a refined discussion, for which astronomers will look with interest to the continuation of the investigation by Messrs Thackeray and Turner, I find that the data of their Plate I. may be very satisfactorily represented by the expression

$$+0''\cdot09-0''\cdot141\cos(t-1885\ \text{Apr. } 23)\times 0^{\circ}\cdot835-0''\cdot148\cos(\odot-300^{\circ}) \quad (A)$$

The law on p. 100, *Astronomical Journal*, No. 277, gives

$$-0''\cdot120\cos(t-1885\ \text{Apr. } 9)\times 0^{\circ}\cdot835-0''\cdot110\cos(\odot-350^{\circ}).$$

The testimony of these observations is consequently entirely in harmony with the law in question, as will strikingly appear if the curve computed from equation (A) be entered upon Plate I. in the November *Monthly Notices*. Such a chart is given on Plate III.* The curve of equation (A) is represented by a dotted line; the observations by a zigzag continuous line, taking for the points of the latter the means of each successive three points, as given by Messrs. Thackeray and Turner, in order to eliminate, unobjectionably, the larger accidental errors.

These results tend still further to confirm the doubt expressed on p. 71, *Astronomical Journal*, No. 273, as to whether temperature-variation plays any significant part in the apparently anomalous results of this instrument, as has always been supposed. This matter has been the subject of a good deal of past investigation, but never with distinctly satisfactory conclusions; and in view of the new light which this freshly discovered annual

[* It was pointed out by Mr. Thackeray, but, unfortunately, not until after this plate had been printed off, that the theoretical curve is apparently one year in error. The portion for 1891 really belongs to 1890, and so on.—Secretaries.]

term in the variation of latitude will probably throw on it, the problem must be again examined, and exhaustively. It is hoped that Messrs. Thackeray and Turner will again cover the already well-travelled ground back to 1851.

I beg to add a remark on an important point. It might be maintained that the annual term in the latitude-variation is illusory, and merely the indication of a generally prevailing instrumental disturbance, due to temperature, and affecting all instruments and methods alike. This would be possible, but, in view of the actual facts, it is not at all probable. This explanation would require the maximum and minimum phases to occur in midwinter and midsummer, and at the same dates in all longitudes. This is not the case. The American observations, with the apparent exception of one series, place these phases three or four months earlier than the European; indicating a rotation from west to east for this annual term, the same as has already been proved, from the observations, for the 427-day term, independently of the theoretical considerations which require it to be so.

1892 *December* 26.

Latitude Variation and Greenwich Observations, 1851–91.
By W. Grasett Thackeray.

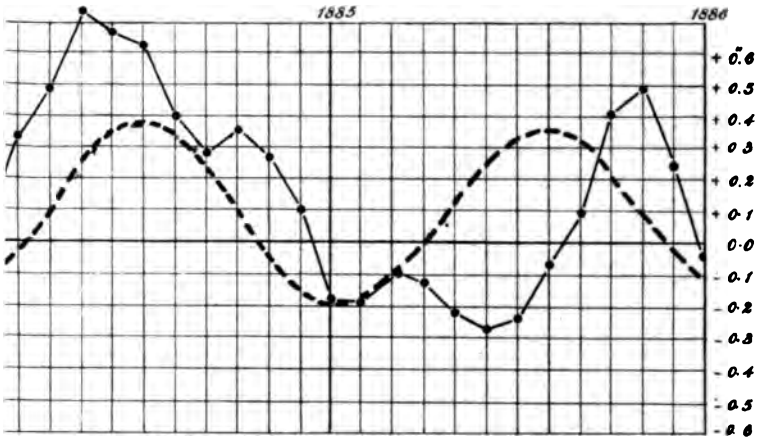
A preliminary paper on this subject was communicated to the Society in November last by Mr. Turner and myself. In it there was found to be indisputable evidence of the Chandler wave period, and grounds were shown for suspecting a five-yearly disturbance. This paper will be found to deal with—

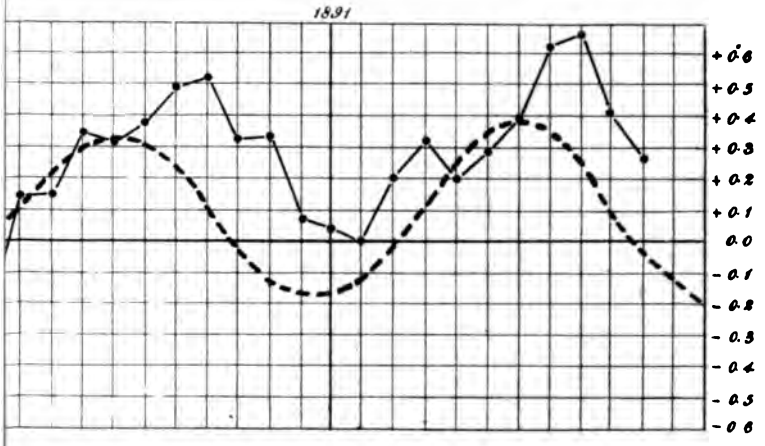
1. The verification of the Chandler curve, as given in No. 277 of the *Astronomical Journal*;
2. The vindication of the correctness of the Greenwich Transit Circle Observations, more especially 1851–65.

1. The verification of the Chandler curve.

Since the publication of the first paper, the observations made at Honolulu and the allied observatories have added their testimony to the existence of a latitude variation, and Mr. Chandler in No. 277 of the *Astronomical Journal* has interpreted afresh the results of the laborious investigations he has undertaken on this subject. For a single term with a varying period he has substituted the resultant curve of two periodic fluctuations. The first of these two terms he has shown to have a period of 427 days and a semi-amplitude of about $0''\cdot12$; the second an annual period depending on the Sun's longitude with a semi-amplitude ranging between $0''\cdot04$ and $0''\cdot20$ during the last half century. In the same paper are also given curves showing the theoretical value of the latitude from 1840–1894 and the twenty-days' groups of observations from 1840–1891 upon which the theory was founded.

This theoretical curve and the observations on which it depends have been compared with the Greenwich observations as


1885
1886
+ 0.6
+ 0.5
+ 0.4
+ 0.3
+ 0.2
+ 0.1
0.0
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6


1891
+ 0.6
+ 0.5
+ 0.4
+ 0.3
+ 0.2
+ 0.1
0.0
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 0.6

represented by the monthly means of the four close circumpolars *Polaris*, *Cephei* 51, δ *Ursæ Minoris*, and λ *Ursæ Minoris* for the years 1880–1891. The observations are taken from the N.P.D. ledgers of the volumes of Greenwich Observations, are reduced with Bessel's Refractions, and to the co-latitude value of 21″·90, and are not corrected for flexure or R—D: that is, where they have been corrected for flexure they have been recorrected to make the flexure = ·00. For discussions on the subject of the value of the correction for flexure as derived from the observations on the collimators, reference should be made to papers on Greenwich North Polar distances by Mr. Christie in *Memoirs R.A.S.*, vol. xlv., and by Professor Newcomb, in vol. ii. of the Astronomical Papers of the American N. A. office. The mean monthly values have been reduced to the epoch 1885. The precessions corresponding to the R.A. of each star at the middle of each year have been taken from Folie's Tables, and added together to reduce the results of the several years to the epoch 1885. The proper motions were taken from the Ten-Year Catalogue.

The differences between the monthly means thus reduced to 1885 and the adopted place for 1885 were then formed by taking monthly mean minus adopted place, both for above and below pole observations, and were combined with weights according to the number of observations.

The adopted places for 1885 were as follows:—

Polaris	...	...	...	...	1	18	16″·15
Cephei 51	..	...	...	...	2	46	33·98
δ Ursæ Minoris		...	...	...	3	23	22·27
λ Ursæ Minoris		...	...	...	1	2	40·18

As these stars are all close to the pole, any correction as now applied for R—D or flexure will be practically the same for all of them, and as the R—D variable term is found to be practically constant for these years, will only affect the zero line. Any error in the adopted places will, however, affect the form of the curve unless the above and below pole observations in any month are equal. Separate curves were also formed including and excluding the daylight observations of *Polaris* and *Polaris s. p.*, from which it was evident that there was no systematic error due to the daylight observations.

These differences, the same as were published in the first paper in November, were finally smoothed by taking the means of every three. It may be remarked that from the end of 1885 to the beginning of 1889 Mr. Chandler appears to have had no observations under investigation. The general accordance between all three curves is wonderfully good, and therefore the divergence of the Greenwich Observations at the beginning of 1881 is to be scanned with the more critical eye.

Mr. Chandler's curves representing theory and the twenty-days' groups of observations have been copied direct from his paper. It was occasionally found a little difficult to follow the latter.

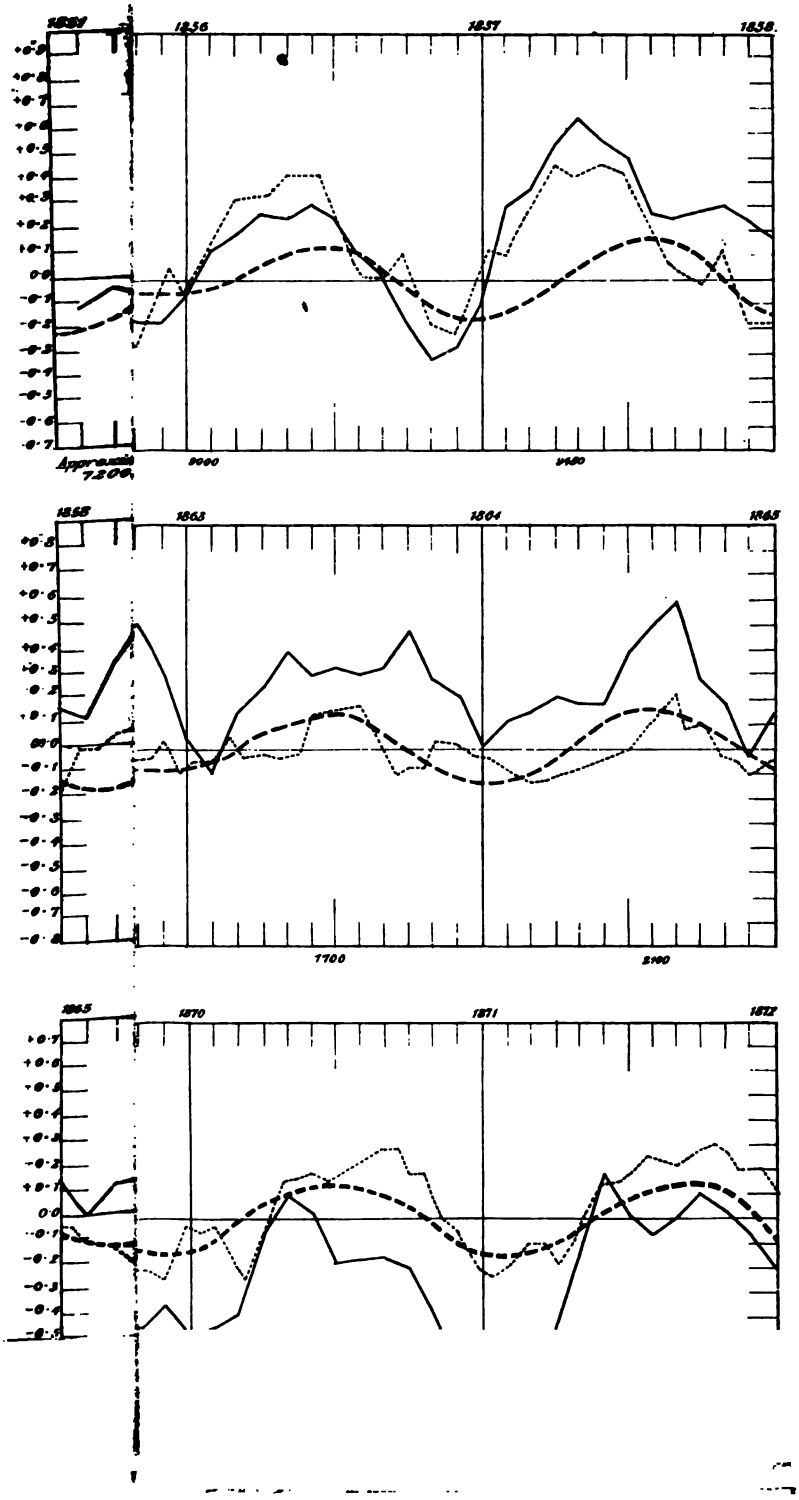
2. The vindication of the correctness of the Greenwich

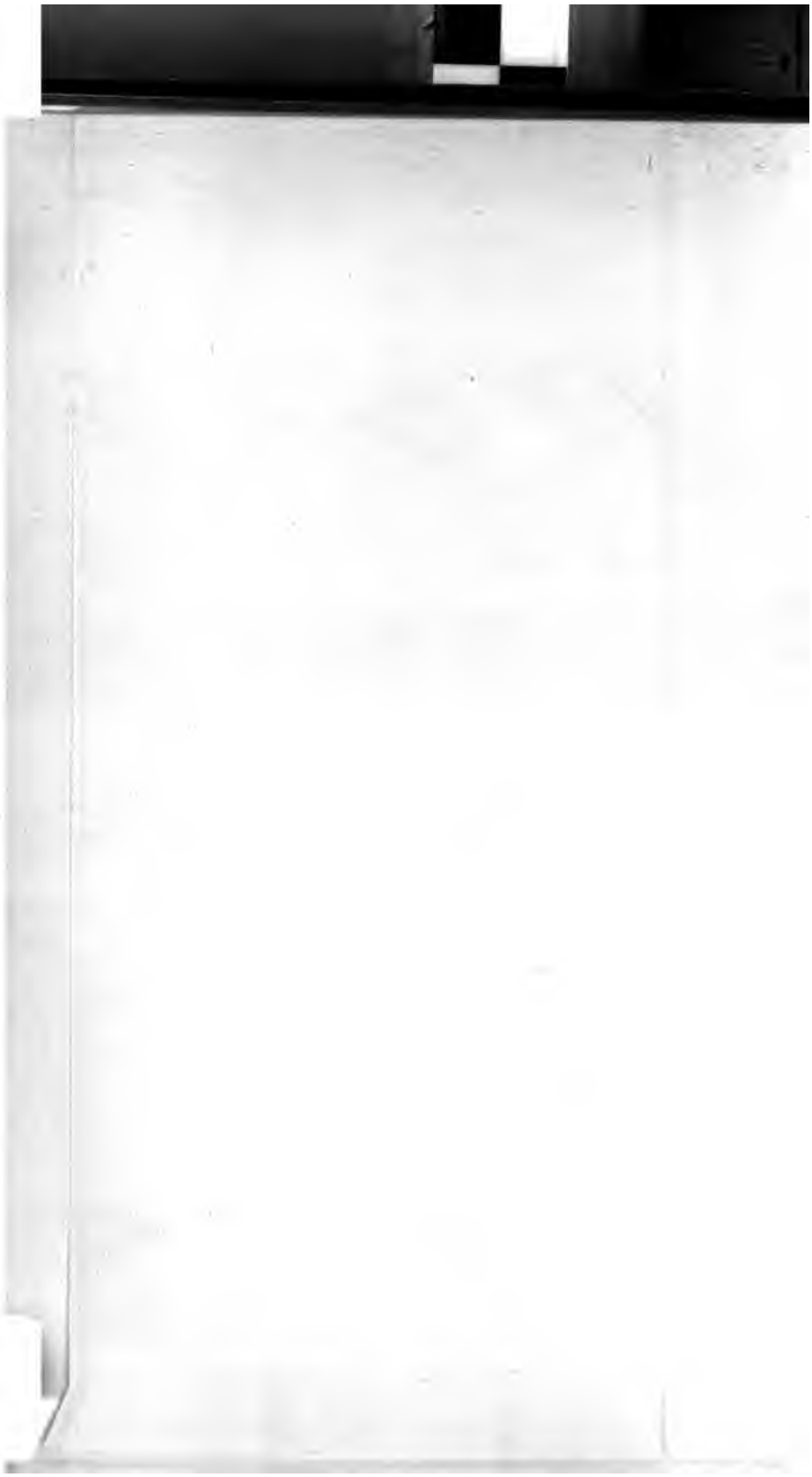
Transit Circle observations in general, and those for 1851–1865 in particular.

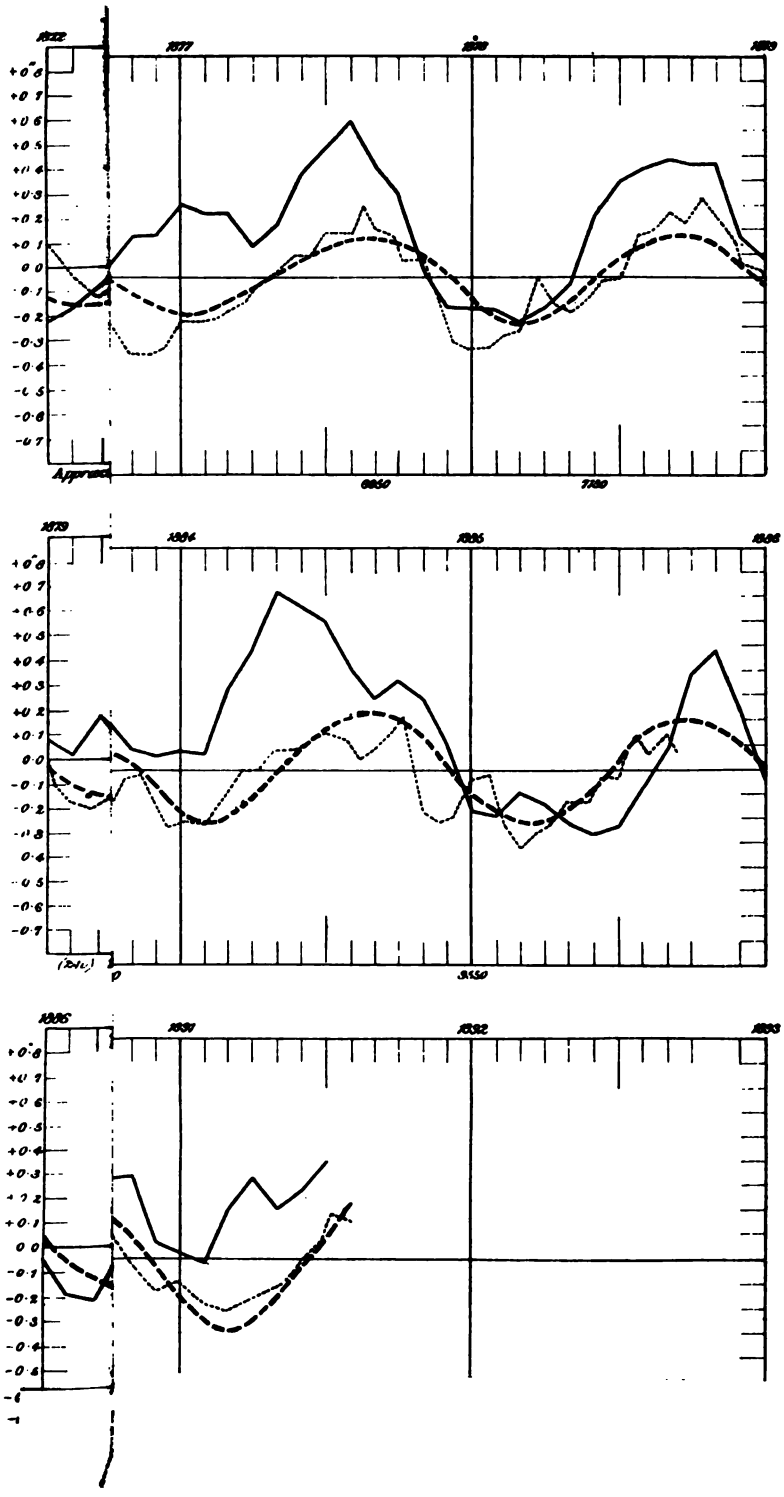
On page 86, No. 251 of the *Astronomical Journal*, Mr. Chandler makes remarks to the following effect:—That the Greenwich observations with the Transit Circle for 1851–65, complicated with instrumental error and large accidental errors of observation, seem to frustrate efforts to get any pertinent results. We at Greenwich have noticed for some time a disposition among foreign astronomers to disparage the Greenwich observations. Scattered up and down foreign astronomical literature remarks such as the following may be found far too frequently:—The results are not accordant; the instrumental errors are complicated; the accidental errors are large and abundant; the observations have been rejected. To such I would remark that uniformity is not synonymous with truth, and that systematic errors are oftentimes the penalty of close agreement; it is to discordant and not to accordant observations that astronomy owes its most brilliant discoveries. In the volume of *Greenwich Observations* every step in the reductions is clearly set down, and the details of all instrumental errors carefully published. A discordant observation at Greenwich has never been rejected simply because it was discordant; but all results have been published, so that anybody using the observations can exercise his own discretion in retaining or rejecting such observations. The fact that Mr. Chandler has, after careful consideration, rejected sixteen years of observations with the Greenwich Transit Circle in such an important investigation as that on which he is engaged, and prefers to use the results of the Reflex Zenith Tube, is so striking that it becomes imperative to closely inquire into the subject. For this purpose I have taken the observations of the four close circumpolars as the representatives of the Greenwich Transit Circle observations.

The observations now under discussion comprise the rest of the series of the Greenwich Transit Circle observations—that is, from 1851–1879. The same stars have been used, the same method of reduction adopted, Bessel's Refractions, colatitude 21″·90, and no correction for flexure or R – D. The observations from 1851–1867 have all been reduced to the epoch 1860, and the observations from 1868–1879 to the epoch 1875. The precessions have been found in the same way, and the results found in an exactly similar manner, and compared with Mr. Chandler's curves representing his latest theory (that is law of eq. 15, *A. J.*, No. 277), and the twenty-day groups of observations on which his theory is based. The following are the adopted places of the stars at the two epochs:—

Epochs	1860	1875
	° ′ ″	° ′ ″
Polaris	1 26 12·90	1 21 26·30
Cephei 51	2 45 6·00	2 45 55·30
δ Ursæ Minoris	3 23 53·20	3 23 32·50
λ Ursæ Minoris	1 6 35·23	1 4 8·40


1856
1857
1858
+0·8
+0·7
+0·6
+0·5
+0·4
+0·3
+0·2
+0·1
0·0
-0·1
-0·2
-0·3
-0·4
-0·5
-0·6
-0·7
Approximate
7200
9000
1860
1863
1864
1865
+0·8
+0·7
+0·6
+0·5
+0·4
+0·3
+0·2
+0·1
0·0
-0·1
-0·2
-0·3
-0·4
-0·5
-0·6
-0·7
-0·8
1700
2100
1865
1870
1871
1872
+0·7
+0·6
+0·5
+0·4
+0·3
+0·2
+0·1
0·0
-0·1
-0·2
-0·3
-0·4
-0·5




1877
1879
1932
+0·8
+0·7
+0·6
+0·5
+0·4
+0·3
+0·2
+0·1
0·0
-0·1
-0·2
-0·3
-0·4
-0·5
-0·6
-0·7
Approach
6950
7159
1879
1894
1895
1896
+0·8
+0·7
+0·6
+0·5
+0·4
+0·3
+0·2
+0·1
0·0
-0·1
-0·2
-0·3
0·4
-0·5
-0·6
-0·7
(Zola)
D
8450
1895
1897
1902
1903
+0·8
+0·7
+0·6
+0·5
+0·4
+0·3
+0·2
+0·1
0·0
-0·1
-0·2
-0·3
-0·4
-0·5

For the years 1868–1874 an additional correction, due to wear of the micrometer screws, is required, for particulars of which reference can be made to the Nine-Year Catalogue, 1872, in the introduction to which catalogue will be found a full and complete explanation. The results of the Greenwich observations thus corrected and reduced to one homogeneous system, when compared with the observations which Mr. Chandler has gathered together from all parts of the world, show a wonderful similarity of contour and general agreement in detail, the more remarkable when it is considered that many of the observations so collected by Mr. Chandler were made for special purposes with special instruments, with a special view to a discussion of this character. The agreement between all the curves is so good that the deviations become all the more accentuated, and, as Mr. Chandler remarks, in speculations on this subject it seems desirable to hold to a prudent reserve for further investigation. Incidentally to this investigation several other important questions have arisen, which are still under discussion.

Nova Aurigæ. By Isaac Roberts, D.Sc., F.R.S.

A photograph of the region of *Nova Aurigæ* was taken on October 3, 1892, with the 20-inch reflector, and exposure of 110 minutes, upon which the *Nova* appears as a star, as well defined as any of the other stars, which are very numerous, on the plate. There is no trace of nebulosity surrounding the *Nova*, or in its vicinity, and there is no feature about it suggestive that it is different from other stars. The diameter of its photo-image measures 21 seconds of arc, and about 85 seconds distant from it, on the *n.f.* side, is a star the photo-image of which measures 23 secs. of arc; the *Nova* is therefore 2 seconds in diameter less than the star.

On December 25, 1892, another photograph was taken of the same region, with an exposure of 20 minutes, upon which the *Nova* has a photo-image of 13 seconds of arc in diameter, and the star referred to has a diameter of 16 seconds. If we proportion the measured diameters obtained on the days stated, we shall have the following:—

$$23'' : 16'' :: 21'' : 14''{\cdot}63, \text{ the diameter of } Nova.$$

But the diameter of the *Nova* measures only 13 seconds, which shows a decrease of $1''{\cdot}63$ in diameter between October 3 and December 25.

There is no indication of nebulosity round the *Nova*, or in its vicinity, on the December plate, and it appears as sharply defined as the other stars.

So far, therefore, as the evidence obtained by the eleven

photographs which I have taken between the date of the appearance of the *Nova* and December 25, there is nothing upon them indicative of a disturbance, such as we might expect to see recorded if a body of the magnitude and velocity of the *Nova* had rushed into a nebula, or into a swarm of meteors. On the other hand, it might be argued that the great velocity of the star would carry it through without causing such great disturbance at right angles to the line of flight, according to dynamic law, that a projectile at a high velocity will penetrate through a plate of iron, or of glass, without fracturing them in the manner that a projectile would at a low velocity. On this hypothesis the inrush of the nebulous or meteoric matter, to fill the vacuum created by the star, might account for the peculiar spectra which were observed.

Photograph of the Nebula H I. 55 *Pegasi.* By Isaac Roberts, D.Sc., F.R.S.

The photograph of this nebula, now presented, was taken with the 20-inch reflector on 1892 October 22, and exposure of 4 hours. The scale is 30 seconds of arc to one millimetre. R.A. $23^h\ 0^m$; Decl. N. 11°45′, at the centre.

The nebula is No. 4892 in the General Catalogue, and is described as pretty bright, considerably large, much elongated towards 12° between two stars, irregularly round, two or three stars in it, pretty generally much brighter in the middle. It is figured in the *Phil. Trans.*, 1833, pl. 14, as a faint ray, with a faint star near each extremity.

Lord Rosse, in his "Observations of Nebulæ and Clusters," p. 170, describes the appearance of the nebula, and it is figured in the *Phil. Trans.* for 1850, pl. 36, fig. 4. The drawing shows a bright broad boundary on the following side, and on the preceding side of it a circle filled with spiral convolutions, strongly marked. A star is shown in the centre of the convolutions, but later observations, made between the years 1849 and 1876, do not with certainty confirm the spiral structure.

The photograph shows the nebula to be a faint ellipse, with a dense broad line, curved at both ends, forming the major axis. There is a star of about 15th magnitude in the centre of the axis, and there is also a fainter star in the preceding semi-ellipse, but there is no structure visible within it, such as that shown on the drawing by Lord Rosse, and it does not show the semi-ellipse on the following side, which is faintly visible on the photograph. The object is altogether a difficult one, either to see or to photograph.

Photograph of the Cluster H VI. 30 *Cassiopeiæ.*

By Isaac Roberts, D.Sc., F.R.S.

The photograph now presented was taken with the 20-inch reflector on 1892 November 26. Exposure 90 minutes. Scale 30 seconds of arc to one millimetre. R.A. $23^h\ 52^m$; Decl. N. 56° 8′, at the centre.

The following description is given by Sir John Herschel in the *Phil. Trans.* for 1833, p. 480 :—"A most superb cluster which fills the field and is full of stars; generally brighter in the middle but no condensation to a nucleus. Stars 11th to 18th magnitude.

Lord Rosse, in his "Observations of Nebulæ and Clusters of Stars," p. 177, describes the cluster as very coarse; stars quite distinct and no visible nebulosity; dark holes and jagged branches, but no regular arrangement.

The photograph shows the cluster to be in fair accord with the descriptions given by Herschel and Rosse as far as they apply; but in addition it shows patterns, consisting of lines, wreaths, and curves of stars, which on the negative are very prominent features. The photograph confirms the eye observations, that there is no nebulosity in the cluster, and, since it shows every star in its true relative position and magnitude, down to about the 16th, the further evolution of this cluster may henceforth be strictly followed by us and by our successors.

The Eclipse of the Moon, 1892 November 4–5. Observed at Sydney Observatory.

(*Communicated by H. C. Russell, B.A., F.R.S., Government Astronomer.*)

The weather was most unpromising for observation, owing to the ever-changing and too abundant clouds; however, at $11^h\ 45^m$ through a break in the clouds, a slight shade, the effect of the penumbra, was visible on the eastern limb of the Moon, and the first contact with the shadow was seen at $12^h\ 14^m\ 20^s$. At $12^h\ 17^m$ the first photograph was taken, and a few minutes later an extensive cirrus-cloud covered the Moon, and a large halo was visible for a time. The cloud continued to increase, and interfered very much with observation. There was no sign of coppery colour, the shadow being so dark—a very dark brown, almost black—that it entirely blotted out the Moon's limb and markings on the surface, which are usually seen through it on such occasions. At $12^h\ 43^m$ a partial break in the cloud gave opportunity for another photograph, exposed 30^s. At $12^h\ 53^m$ the Moon was half eclipsed and the clouds had become thicker, so much so that no features of the Moon were visible through the shadow or eclipsed part of the Moon. At $12^h\ 55^m$ another photograph was taken, and the exposure was increased to 1^m.

At $1^h\ 28^m$ A.M. the eclipse was announced to become total, but here the Moon did not become wholly involved in the shadow.* The white strip of Moon visible at the total eclipse travelled round the northern limb of the Moon as the eclipse proceeded.

At 2 A.M. clouds cleared a little, and it could be seen by its coppery tint that the Moon was passing gradually out of the very dark part of the Earth's shadow-cone into a lighter part, in which the usual coppery-red light was bright enough to illuminate the Moon. On the northern side of the Moon, and extending upwards, the red or coppery colour seemed to involve three-fourths of the Moon, and a few minutes later—$2^h\ 10^m$—the Moon had passed altogether out of the dark shadow, and the whole of it was visible in red light. At $2^h\ 12^m$, the end of total eclipse, the white patch already referred to was on the N.E. side, and the colours on the Moon were unusually beautiful. A minute white crescent on the N.E. was fringed by greenish-grey light, which seemed to extend the crescent half round the Moon and hold in its grasp a brilliant coppery-red ball, the whole Moon, of which the lightest red was next the greenish-grey crescent, presenting altogether the most beautiful view of an eclipsed Moon that I have ever seen. At $2^h\ 30^m$ A.M. clouds again covered the Moon until six minutes past 3 A.M. At $3^h\ 8^m$ A.M. another photograph was taken. The coppery colour had gone, and the shadow on the Moon looked nearly as black as it did at the beginning of the eclipse. At $3^h\ 24^m$ A.M. another photo was taken. The last contact was observed $3^h\ 26^m$ A.M., and the penumbra still cast a faint shadow over part of the Moon, and three minutes later clouds again claimed possession. Six successful photographs of the Moon were obtained.

Observatory, Sydney N.S.W.:
1892 *November* 5.

Estimations of Magnitude of Nova Aurigæ, made at the Radcliffe Observatory, Oxford. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

Estimations of the magnitude of the Nova have been made on the following nights: 1892 November 18, 26; December 9, 12, 22, 23; and 1893 January 2 and 10. The mean magnitude given by these observations is 9·7, and it would appear that no sensible changes of magnitude have taken place during the interval over which these observations extend.

Radcliffe Observatory:
1893 *January* 12.

[* The Superintendent of the *N. A.* kindly informs us that "the Moon's centre was north of the shadow's centre, so that the Moon's north limb was close to the edge of the shadow, and small errors in adopted values might make it visible. The diameter of the shadow is increased in a certain proportion for one thing, but this assumed enlargement probably varies with the atmospheric conditions at the time of each eclipse."—Secretaries.]

Observations of the Variable Star S Ursæ Majoris. R.A. xii. 39. 7; Dec. 61° 41′ 8 N. By Cuthbert E. Peek, M.A.

The above is one of the long-period variable stars under regular observation, and the series just presented covers a period of six years, extending from 1886 July to 1892 June.

The sketch diagram appended shows most of the stars near the variable; several are conspicuous, and the field can be identified without difficulty. Six of the stars are to be found in Argelander's chart, and using these as a basis the magnitudes of the remainder were determined by taking the mean of several series of careful eye estimations. This was done in 1886, and on the receipt of Prof. Pickering's work, *Variable Stars of Long Period*, in 1891, several of the Rousdon magnitudes of these comparison stars were found to be identical with those determined at Harvard Observatory, the mean difference being ·5 magnitude in excess. The necessary correction has been applied throughout; these observations, therefore, are strictly comparable with those of Harvard College. It will be seen from the annexed table that the Harvard College magnitudes are only estimated to the nearest whole magnitude.

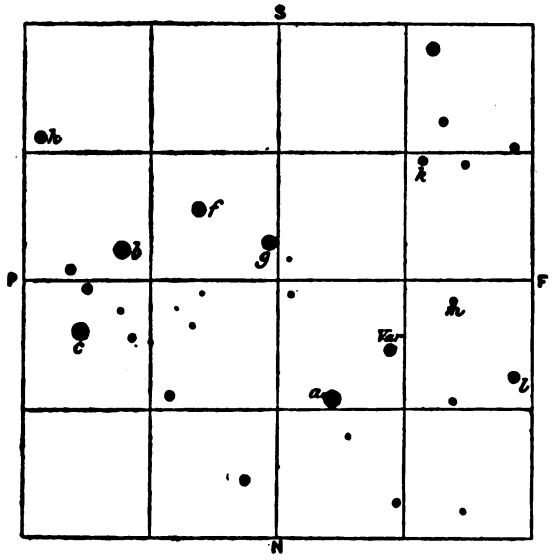
The light varies to the extent of about five magnitudes, the brightest maximum being 7·3 magnitude, and the faintest minimum 12·5 magnitude. It is always more or less red, and generally well defined, in contradistinction to some other variables which on several occasions have been noted as somewhat similar to a planetary nebula when other stars in the field could be brought to an absolutely sharp focus.

The observations were made with a $6\frac{4}{10}$ inch achromatic equatoreal telescope, the eyepieces commonly in use giving powers of 36, 80, and 136.

Argelander's method of observation has been followed throughout, the usual practice being to compare the variable with five other stars, the mean resulting magnitude being entered for the date given. Observations have been made on 146 nights, and 10 maxima and minima have been recorded. The dates of the maxima and minima given are the actual dates when the greatest and least brightness was observed. On the diagram the dots representing observations are simply joined by straight lines.

Several interesting irregularities are shown. The abrupt pause in the increase, and tendency to form small maxima, are well shown in 1887 February and March, and again in September and October. The pause in 1888 March and April was unusually long. About the maxima in 1890 November and 1891 July the light curve was much flatter than usual and the irregularities greatly diminished. At the maximum in 1892 March the contrary was observed, and the curve was more sudden than at any other maximum of this series. The light at various maxima has been observed to range from 7·5 to 8·2 magnitude.

Towards the minima several smaller irregularities are observed. A short pause is seen in the downward curve in 1886 November and 1888 February. At the minimum between these dates the light curve was abnormally flattened, and between June 16 and August 4 the star only declined ·5 magnitude. Before the minimum on 1888 September 30, the star showed a temporary minimum and sudden increase. It is open to question whether the magnitude given as the minimum on 1891 April 15 represents actually the least brightness, as the light curve seems to show that, had more frequent observations been possible, a lower magnitude would have been registered. The light at minimum has been observed to range from 11·5 to 12·5 magnitude.

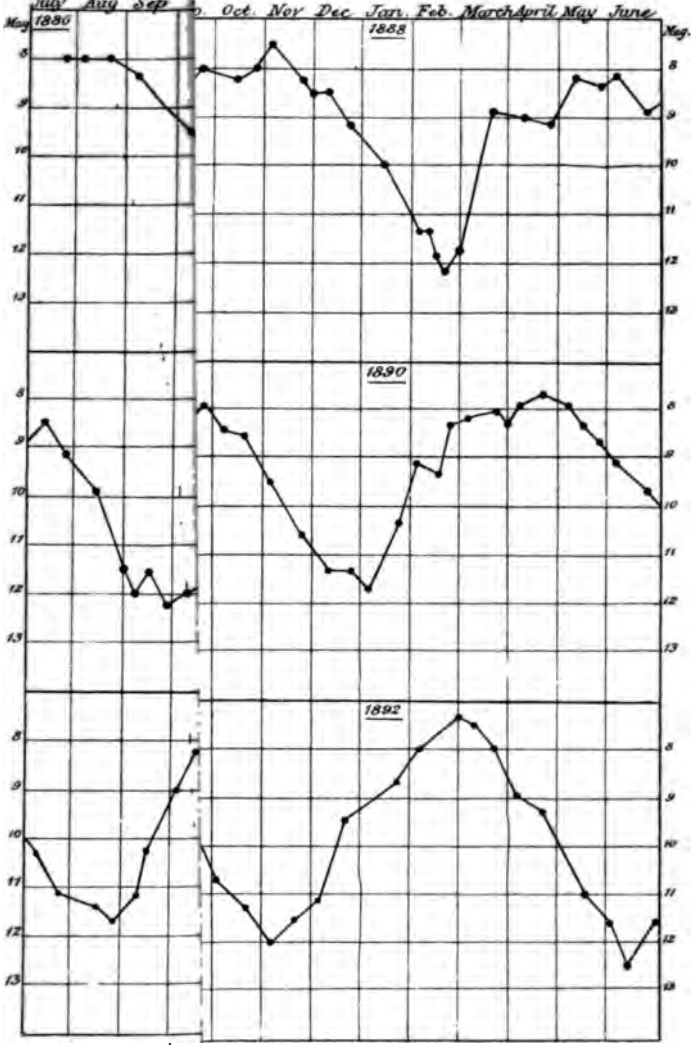


(One square degree.)

Harvard Magnitudes:

a	6 mag.	*c*	7 mag.	*g*	9 mag.	*k*	10 mag.
b	7 „	*f*	9 „	*h*	10 „	*l*	10 „
				m	11 mag.		

The table of maxima shows great irregularities, the intervals ranging from 212 to 240 days. The mean period, however, of the 10 maxima is 225·6 days, a result differing only ·8 day from the period given in *A Revised Catalogue of Variable Stars*, by J. E. Gore. The table of minima shows still greater irregularities. There is a difference of forty-seven days between the longest and shortest intervals, and at the minimum of 1889 May 10 the difference between the predicted and observed dates amounted to no less than sixty-two days.


July
Aug
Sep
Oct
Nov
Dec
Jan.
Feb.
March
April
May
June
Mag.
1886
1888
1890
1892

With regard to the actual observations, it may be mentioned that at the telescope the diagram, containing the stars indicated by letters, is alone used, the register of magnitudes being kept in the computing room. By this means an impartial observation is obtained, it being clearly impossible to remember the magnitudes of the (approximately) 300 comparison stars used in the observation of the variables on the working list.

The observations have been, in great part, made by my assistant, Mr. C. Grover, checked on all available opportunities by myself.

Observations of S Ursæ Majoris.

Maxima.

Date.	Mag.	Interval.	Predicted Date.	Authority.	Difference between Predicted & Observed.
		days			days
1886 Aug. 9	8·0	...	July 24	N. and C.O.	−16
1887 Mar. 27	7·8	230	Mar. 10	C.O.	−17
Nov. 1	7·6	219	Oct. 29	C.O.	− 3
1888 June 9	8·2	221	June 9	N. and C.O.	
1889 Feb. 4	7·6	240	Mar. 7	Sch.	+31
Sept. 22	7·9	230	Oct. 26	C.O.	+34
1890 April 22	7·7	212	April 27	C.O.	+ 5
Nov. 27	8·0	219	Dec. 9	C.O.	+12
1891 July 18	7·9	233	July 24	C.O.	+ 6
1892 Mar. 1	7·3	227	Mar. 6	C.O.	+ 5

N. = *Nature.*

C.O. = *Companion to the Observatory.*

Sch. = Schönfeld.

Observations of S Ursæ Majoris.

Minima.

Date.	Mag.	Interval.	Predicted Date.	Authority.	Difference between Predicted & Observed.
		days			days
1886 Dec. 15	12·5	...	Nov. 14	C.O.	−31
1887 Aug. 4	11·5	232	July 1	N. and C.O.	−34
1888 Feb. 16	12·2	196	Feb. 15	N. and C.O.	− 1
Sept. 30	12·3	227	Oct. 1	N. and C.O.	+ 1
1889 May 10	12·5	223	July 11	C.O.	+62
1890 Jan. 8	11·7	243			
Aug. 23	11·7	228	Aug. 24	C.O.	+ 1
1891 April 15	11·7	235	April 7	C.O.	− 8
Nov. 3	12·0	202	Nov. 19	C.O.	+16
1892 June 11	12·5	221	July 2	C.O.	+21

Comparison Stars for S Ursæ Majoris.

	Harvard.	Rousdon.
a	6·0	6·0
b	7·0	7·0
c	7·0	7·3
f	9·0	8·6
g	9·0	9·0
h	10·0	10·1
k	10·0	9·8
l	10·0	10·1
m	11·0	10·9

Rousdon Observatory, Lyme Regis:
1892 *September* 19.

The Geminid Meteor Shower, 1892 *December* 12.

By W. F. Denning.

The night of December 12 appears to have been clear over the country generally, and observations were obtained at many places. It is probable, however, that the Geminid display had then passed its maximum.

Professor A. S. Herschel, at Slough, watched the western sky during three hours of the interval between $10^h\ 45^m$ and $14^h\ 38^m$, and registered the paths of twenty-four shooting stars. Five others had been recorded earlier in the same night. The radiant of the Geminids was not very active nor its position sharply defined, most of the tracks of the conformable meteors having been observed at a considerable distance from it. Some conspicuous meteors were recorded which belonged to the numerous minor showers of the epoch, including Ursids, Leonids, Perseids, &c.

Mr. H. Corder, at Bridgwater, counted sixty-six shooting stars during watches covering about $5\frac{1}{4}$ hours (6^h to 8^h, and 10^h to $13^h\ 15^m$). He found the chief Geminid radiant at $109°+34°$ (38 meteors), and there was a secondary display at $117°+30°$ (12 meteors).

At Bristol I looked towards the eastern sky during a period equivalent to $1\frac{1}{2}$ hour between $9^h\ 45^m$ and $11^h\ 30^m$, and observed twenty shooting stars, of which about fifteen were Geminids. The chief radiant point was at $119°+29°$, $4\frac{1}{2}°$ E. of *β Geminorum*, and the centre of the true Geminids appeared to be indistinctly marked at $107°+34°$ from six tracks. The two showers are, I believe, quite separate; that from near *β Geminorum* usually gives brighter and longer meteors than the companion radiant N.W. of *α*. I had already seen this pair of contemporary

showers in the first half of December 1885, and on that occasion detected a third at 110°+25° (11 meteors).

The radiant of the true Geminids as independently determined by several observers this year on Dec. 12 was as under:—

Position. α δ	No. of Meteors.	Observer.	Place.
112°+38°	6	A. S. Herschel.	Slough.
109+34	38	H. Corder.	Bridgwater.
110+32	14	D. Booth.	Leeds.
107+32½	17	E. R. Blakeley.	Dewsbury.
109+30	5	W. H. Milligan.	Belfast.
107+34	6	W. F. Denning.	Bristol.

Evidence is not wanting to show that the diverging centre of this shower, like that of the great Perseid display in July–August, moves to the eastwards, but my observations of the earlier and later stages of the December stream are not sufficiently numerous to be conclusive on the point. I have certainly seen Geminids falling from α 103°—105° on the first few nights of December, whereas on the 9th the centre has been at α 107°, and on the 12th at α 109°. It is rather difficult to register the exact paths of these meteors, as they commonly traverse short, quick courses, and, except in regard to the brighter ones, streaks or trains rarely accompany them in their flights, so that there is nothing to guide the eye in its hurried effort to retain the directions accurately.

As to the neighbouring shower east of *β Geminorum*, this and previous years' observations define the mean place of it at 116°+30° from the following observations:—

Date.	Position. α δ	No. of Meteors.	Observer.
... December 7–13	118°+26°	13	Heis Cr_m.
1880 December 9	116+31	5	Backhouse.
1880 December 11	115+31	19	Backhouse.
1884 December 11	115+30½	...	Sawyer.
1885 December 7–8	115+33	11	D. 861.
1885 December 9–10	117+32	10	D. 877.
1892 December 12	117+30	12	Corder.
1892 December 12	119+29	8	D.

There is a well-pronounced shower, apparently from the same point in the sky, at the close of the year, for in 1886 December 22 to 29 I obtained a radiant at 115°+32° from seven slow meteors (=D. 907).

During recent observations the following bright meteors were recorded:—

Date. 1892.	G.M.T. h m	Magnitude.	Apparent Path. From α °	From δ °	To α °	To δ °	Probable Radiant.	Appearance.	Observer.
Dec. 9	7 30±	Very bright.	59½	+21¾	39½	+2¾	Gemini. 103°+38°.	Very slow, train.	"H.W.M."
	7 39±	1	85	+35	75	+34		Streak.	H.C.
	7 39	>1	81	+32	61	+22		Very slow, streak.	W.F.D.
	8 15±	1	70	+71	87	+60	333+73.	Slow, train, orange.	H.C.
	11 0	1	180	+62	209	+59	Gemini.	Orange.	H.C.
11	8 9	>1	71	+16½	62	+10	Gemini.	Streak.	H.C.
	9 23	1	343	+35	332	+32	Musca.	Streak.	H.C.
12	7 37	Capella.	95	+43	76½	+47	Gemini.	Streak, yellow.	H.C.
	9 54	1	130	+19½	132	+17½	Gemini.	Very slow, star-like.	W.F.D.
	10 10	2+♀	150	+43	188	+41	Gemini.	Rather slow.	D.B.
	10 51	>1	110	+38	109	+44	Gemini. 110½+35.	Very slow, streak, duration 2½°.	W.F.D.
	10 51¾	Sirius.	14	+38	359	+27		Streak, duration 1°·1.	A.S.H.
	10 55±	1	135	+46	149	+50		Streak, yellow.	H.C.
	11 22	¼	55	+41	45	+20	190+58.	Streak 1°, duration 1°·2.	A.S.H.
	11 39	¼	19	+ 1	21	− 4	16+7.	Wavy course, duration 1°·4, intermittent light.	A.S.H.
	12 20	1½	58	+59	30	+60	Gemini.	White.	H.C.
	12 48	1	143	− 3	148	−10	Gemini.	White.	H.C.
	13 28	1	210	+68	260	+63	153+42.	Streak, duration 1°·1	A.S.H.
	14 18	Vega.	19	+41	25	+27	333+73.	Streak, duration 1°·5	A.S.H.

Observers: Professor Herschel and Messrs. Corder, Booth, and Denning.

On comparing together all the available observations, three of the same meteors were found to have been observed at more than one station. On December 9, $7^h\ 39^m\pm$, a fine slow-moving Geminid, leaving a bright streak, was recorded at Bridgwater, Worcester, and Bristol. On December 12, $10^h\ 52^m\pm$, another bright member of this shower, estimated by Professor Herschel as equal to *Sirius*, was seen at Slough, Bridgwater, and Bristol, and on the same night, at $11^h\ 20^m$, a 2nd mag. Geminid was observed at Bridgwater and Bristol. Combining the various data, I have obtained the following results:—

Real Paths of 3 Geminids, 1892.

Particulars.	(1) Dec. 9. $7^h\ 39^m$	(2) Dec 12. $10^h\ 52^m$	(3) Dec. 12. $11^h\ 20^m$
Height at beginning	91 miles	60 miles	85 miles.
Position over	Ilford, Essex	Hungerford	5 miles north of Lynmouth.
Height at ending	57 miles	36 miles	44 miles.
Position over	Whitchurch, Hampshire	Chippenham	Lat. N. 51° 25′. Long. W. 4° 23′.
Earth point	Totnes	Magor, River Severn	10 miles south of Milford Haven.
Real length of path	75 miles	31 miles	50 miles.
Velocity per second	30 „	20 „	38 „
Radiant point	103° + 38	110½° + 35°	111° + 34°
Direction of flight from azimuth W. of S.	243°	277°	284°
Inclination (= alt. of radiant)	28	52	55

Bristol:
1892 *December* 26.

Observations of Brooks' Comet (g 1892) made at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The observations were made with the East, or Sheepshanks, Equatoreal, aperture 6·7 inches, by taking transits over two cross wires at right angles to one another, and each inclined 45° to the parallel of declination. Transits were occasionally taken also over a third wire, bisecting the angle between the other two wires. Magnifying power, 55.

Greenwich Mean Solar Time.	Observer.	☄ − ✱ R.A.	Log. factor of Parallax.	Corr. for Refraction.	☄ − ✱ N.P.D.	Log. factor of Parallax.	Corr. for Refraction.	No. of Comps.	Appt. R.A.	Appt. N.P.D.	Comp. ✱
1892 d h m s		m s		s	′ ″		″		h m s	° ′ ″	
Dec. 12 14 37 25	H.	+0 33·59	9·6194	0·00	− 0 22·0	0·7598	0·0	6	13 40 44·45	61 23 43·1	*a*
12 14 45 12	,,	−0 53·17	9·6169	−0·01	− 8 17·5	0·7530	−0·1	8	13 40 44·54	61 23 5·2	*b*
12 15 8 33	,,	−3 1·58	9·6093	−0·01	−13 4·4	0·7326	+0·1	2	13 40 47·85	61 22 8·3	*c*
15 14 26 11	,,	+0 6·73	9·6380	+0·01	+ 5 50·9	0·7499	+0·1	3	13 51 15·95	57 40 11·3	*d*
15 18 1 28	A. C.	+0 28·26	9·3657	0·00	+ 3 51·2	0·5187	0·0	4	13 51 52·75	57 30 41·9	*e*
23 12 17 55	,,	+2 28·51	9·6483	0·00	− 1 4·3	0·8391	−0·1	4	14 35 39·40	44 54 1·1	*f*
23 12 17 55	,,	+1 11·56	9·6483	0·00	+ 1 19·3	0·8391	+0·1	4	14 35 39·52	44 54 3·3	*g*

Comparison Stars.

	Star's Name.	Mean R.A. 1892·0. h m s	Mean N.P.D. 1892·0. ° ′ ″	Authority.
a	W.B. (2) XIII. 810, 811	13 40 9·41	61 23 41·5	Weisse's Bessel
b	Lalande 25412	13 41 36·28	61 30 59·2	Lalande and Weisse's Bessel
c	Lalande 25467	13 43 48·01	61 34 49·1	Second Armagh Catalogue
d	Lalande 25647	13 51 7·79	57 33 55·0	Lalande
e	B.F. 1917	13 51 23·07	57 26 25·4	Greenwich Ten Year Catalogue, 1880
f	Radcliffe 3235	14 33 9·88	44 54 36·7	Radcliffe Catalogue and Bonn Observations, vol. vi.
g	O.A. (N.) 14741	14 34 26·96	44 52 15·2	Oeltzen-Argelander and Bonn Observations, vol. vi.

Notes.

The observations are corrected for refraction but not for parallax. They are also corrected for the error of inclination of the wires, and, where necessary, for the motion of the comet in N.P.D.

Dec. 12.—No nucleus to comet.

15.—Note by H.: Comet appeared fainter than on Dec. 12. No nucleus. Frequently difficult to see.
Note by A. C.: Comet pretty bright. Small. Central condensation.

23.—Comet fairly bright. Central condensation.

The initials H. and A. C. are those of Mr. Hollis and Mr. Crommelin respectively.

Royal Observatory, Greenwich:
1892 *January* 10.

Observations of Occultations of Stars by the Moon and of Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the year 1892.

(Communicated by the Astronomer Royal).

Occultations of Stars by the Moon.

Day.	Phenomena.	Telescope.	Power.	Moon's limb.	Mean Solar Time of Observation. h m s	Observer.
1892 Feb. 1 (*a*)	Disapp. Piazzi XXIII. 190	E. Equat.	150	Dark	5 57 57·19	L.
1	,, Piazzi XXIII. 190	Altaz.	100	,,	5 57 57·36	H.
1 (*b*)	Reapp. Piazzi XXIII. 190	E. Equat.	150	,,	6 54 0·19	L.
7	Disapp. 118 Tauri (S *)	Altaz.	100	,,	12 45 27·84	H. T.
7	,, 118 Tauri (S *)	E. Equat.	150	,,	12 45 26·90	L.
7	,, 118 Tauri (N *)	Altaz.	100	,,	12 45 29·94	H. T.
7	,, 118 Tauri (N *)	E. Equat.	150	,,	12 45 28·99	L.
Mar. 8	,, o^2 Cancri	,,	150	,,	8 14 46·44	H.
Apr. 2	,, 139 Tauri	Altaz.	100	,,	12 36 22·65	L.
2	,, 139 Tauri	E. Equat.	55	,,	12 36 22·97	A. C.
7 (*c*)	,, 42 Leonis	,,	55	,,	7 50 15·72	C. D.
May 11	,, B D −19° No. 4091	,,	55	,,	10 16 31·50	L.
11	,, B D −19° No. 4091	Altaz.	100	,,	10 16 32·02	B.
11	,, B D −19° No. 4093	Photo. Equat.	225	,,	10 20 26·16	C.
11 (*d*)	Reapp. B D −18° No. 4047	E. Equat.	55	,,	10 31 45.76	L.
11 (*e*)	Disapp. B D −19° No. 4095	Photo. Equat.	225	,,	10 34 56·27	C.
11	,, B D −19° No. 4095	E. Equat.	55	,,	10 34 57·73	L.
11	,, B D −19° No. 4095	Altaz.	100	,,	10 35 (4·01)	B.
11 (*f*)	,, B D −19° No. 4096	Photo. Equat.	225	,,	10 42 34·01	C.

Day.	Phenomena.	Telescope.	Power.	Moon's limb.	Mean Solar Time of Observation. h m s	Observer.
1892 May 11 (*g*)	Reapp. B D −19° No. 4087	Photo. Equat.	225	Dark	10 57 37·53	C.
11	Disapp. O A (S.) 14520	„ „	225	„	11 9 37·56	C.
11	„ O A (S.) 14525–6 (1st ✱)	E. Equat.	55	„	11 12 5·57	L.
11	„ O A (S.) 14525–6 (1st ✱)	Altaz.	100	„	11 12 (8·00)	B.
11	„ O A (S.) 14525–6 (2nd ✱)	Photo. Equat.	225	„	11 12 13·14	C.
11	Disapp. O A (S.) 14525–6 (2nd ✱)	E. Equat.	55	„	11 12 13·35	L.
11	Reapp. B D −19° No. 4091	E. Equat.	55	„	12 33 56·77	L.
July 3	Disapp. Uranus 1 L	Altaz.	100	„	9 8 4·82	H. T.
3	„ Uranus 1 L	Photo. Equat.	225	„	9 8 2·99	C.
3	„ Uranus 2 L	Altaz.	100	„	9 8 10·01	H. T.
3	„ Uranus 2 L	Photo. Equat.	225	„	9 8 11·46	C.
Aug. 11 (*h*)	Reapp. 14 Ceti	„ „	120	„	12 39 37·63	C. D.
Sept. 12	„ κ Tauri	E. Equat.	150	„	12 58 49 87	C. M.
15	„ ω^2 Cancri	Photo. Equat.	120	„	13 42 51·01	C. D.
Oct. 3	Disapp. τ^2 Aquarii	Altaz.	100	„	6 32 1·54	A. C.
Nov. 30	„ Piazzi I. 123 (1st ✱)	Photo. Equat.	225	„	8 8 21·63	C. D.
30	„ Piazzi I. 123 (2nd ✱)	„ „	225	„	8 8 22·13	C. D.
30	„ Lalande 2945	E. Equat.	150	„	8 26 26·86	A. C.
Dec. 25	„ B.A.C. 8214	„	150	„	6 4 9·68	T. H.

Notes.

(*a*) A very good observation. (*b*) Star faint, slight cloud; possibly half a second late; not a good observation.
(*c*) Observation made very hurriedly. (*d*) Observation very rough. (*e*) Considered a good observation.
(*f*) Star very faint. (*g*) Probably a little late; star a little way from limb. (*h*) Reappearance bright and instantaneous.

Phenomena of Jupiter's Satellites.

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1892 Jan. 7	II.	Tr. Egr. First seen	E. Equat.	150	5 21 59	5 20	L.
7	II.	Last contact	,,	,,	5 27 38		,,
June 27	II.	Ecl. D. Last seen	,,	55	14 13 16	14 12 51	B.
27 (*a*)	II.	Ecl. D. Last seen	Photo. Equat.	225	14 13 19	14 12 51	C. D.
30	III.	Tr. Egr. First seen	E. Equat.	150	13 21 5		A. C.
30	III.	Bisection	,,	,,	13 22 32	13 28	,,
30	III.	Last contact	,,	,,	13 25 14		,,
July 22	II.	Ecl. R. First seen	,,	,,	13 51 2		L.
22	II.	Bisection	,,	,,	13 52 32	13 48 55	,,
22	II.	Full brightness	,,	,,	13 53 36		,,
22	II.	Occ. D. First contact	,,	,,	14 5 5	14 6	,,
22	II.	Last seen	,,	,,	14 7 44		,,
Aug. 10	I.	Occ. R. First seen	,,	,,	13 21 33	13 21	B.
11 (*b*)	I.	Tr. Egr. First seen	Photo. Equat.	225	10 37 34		C. D.
11	I.	Bisection	,,	,,	10 39 6	10 40	,,
11	I.	Last contact	,,	,,	10 40 14		,,
12 (*c*)	III.	Tr. Egr. Last contact	,,	,,	12 50 46	12 53	,,
25	II.	,, First seen	E. Equat.	150	9 48 12		L.
25	II.	Bisection	,,	,,	9 51 26	9 52	,,
25	II.	Last contact	,,	,,	9 55 11		,,

Day.	Satellite.	Phenomenon.		Telescope	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1892 Aug. 30 (*d*)	II.	Ecl. D.	Began to fade	Photo. Equat.	225	13 29 52	13 32 12	C. D.
30	II.		Last seen	,,	,,	13 32 24		,,
Sept. 6	III.	Occ. D.	First contact	E. Equat.	150	11 14 37	11 23	L.
6	III.		Last seen	,,	,,	11 19 51		,,
6	III.	Occ. R.	First seen	,,	,,	12 54 22	13 7	,,
6	III.		Last contact	,,	,,	13 7 35		,,
13	III.	Ecl. D.	Last seen	,,	,,	11 39 1	11 38 13	R. C.
17 (*e*)	II.	Ecl. D.	Last seen	,,	,,	7 58 33	7 59 53	A. C.
17	II.	Ecl. D.	Last seen	Photo. Equat.	225	7 58 34	7 59 53	A. E.
17	II.	Occ. R.	First seen	E. Equat.	150	11 40 4	11 41	A. C.
17	II.		Last contact	,,	,,	11 41 59		,,
17 (*f*)	II.	Occ. R.	First seen	Photo. Equat.	225	11 39 48	11 41	A. E.
17	I.	Tr. Ing.	First contact	E. Equat.	150	11 47 44		A. C.
17	I.		Bisection	,,	,,	11 49 3	11 49	,,
17	I.		Last seen	,,	,,	11 50 44		,,
24 (*g*)	III.	Tr. Ing.	First contact	,,	,,	8 0 23	7 58	,,
24	III.		Last seen	,,	,,	8 7 50		,,
24	III.	Tr. Egr.	First seen	,,	,,	9 38 36		,,
24	III.		Bisection	,,	,,	9 41 26	9 42	,,
24	III.		Last contact	,,	,,	9 43 2		,,
24 (*h*)	II.	Ecl. D.	Began to fade	,,	,,	10 32 46	10 35 1	,,
24	II.		Last seen	,,	,,	10 34 45		,,

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1892 Sept. 24	I.	Tr. Ing. First contact	E. Equat.	150	13 31 0		A. C.
24	I.	Bisection	,,	,,	13 33 34	13 33	,,
24	I.	Last seen	,,	,,	13 35 2		,,
24	II.	Occ. R. First seen	,,	,,	13 53 41		,,
24	II.	Bisection	,,	,,	13 54 48	13 56	,,
24	II.	Last contact	,,	,,	13 57 17		,,
Oct. 1	III.	Tr. Ing. First contact	,,	,,	11 11 18		L.
1	III.	Bisection	,,	,,	11 16 27	11 13	,,
1	III.	Last seen	,,	,,	11 24 46		,,
1	III.	Tr. Egr. Bisection	,,	,,	13 0 10		,,
1	III.	Last contact	,,	,,	13 6 19	13 0	,,
1	II.	Ecl. D. Last seen	,,	,,	13 9 45	13 9 13	,,
3	I.	Tr. Ing. Bisection	,,	55	9 41 22		A. C.
3	I.	Last seen	,,	,,	9 42 55	9 42	,,
3	II.	Tr. Egr. First seen	,,	,,	10 34 46		,,
3	II.	Bisection	,,	,,	10 37 22	10 36	,,
3	II.	Last contact	,,	,,	10 40 4		,,
3	I.	Tr. Egr. First seen	,,	,,	11 51 19		,,
3	I.	Bisection	,,	,,	11 52 59	11 54	,,
3	I.	Last contact	,,	,,	11 54 21		,,

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1892 Oct. 9 (i)	I.	Ecl. D. Bisection	E. Equat.	150	14 7 32	14 8 15	T. H.
9	I.	Last seen	,,	,,	14 8 27		,,
18	I.	Occ. D. First contact	Photo Equat.	225	10 19 12		C. D.
18	I.	Bisection	,,	,,	10 21 27	10 21	,,
18	I.	Last seen	,,	,,	10 22 57		,,
18	I.	Ecl. R. First seen	,,	,,	12 41 54	12 41 39	,,
18	I.	Full brightness	,,	,,	12 43 34		,,
25	I.	Occ. D. Last seen	E. Equat.	150	12 5 3	12 5	B.
26	I.	Tr. Ing. Bisection	,,	220	9 19 38	9 18	A. C.
26	I.	Last seen	,,	,,	9 20 59		,,
26	II.	Occ. D. First contact	,,	,,	9 23 56		,,
26	II.	Bisection	,,	,,	9 26 14	9 28	,,
26	II.	Last seen	,,	,,	9 29 23		,,
26	III.	Occ. D. First contact	,,	,,	10 17 47		,,
26	III.	Bisection	,,	,,	10 20 59	10 23	,,
26	III.	Last seen	,,	,,	10 28 44		,,
Nov. 1	I.	Occ. D. First contact	,,	150	13 47 19		,,
1	I.	Bisection	,,	,,	13 49 6	13 50	,,
1	I.	Last seen	,,	,,	13 50 27		,,
18	I.	Tr. Ing. First contact	,,	,,	8 59 30		L.
18	I.	Bisection	,,	,,	9 1 55	9 0	,,
18	I.	Last seen	,,	,,	9 4 30		,,

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation.	Mean Solar Time of N.A.	Observer.
					h m s	h m s	
1892 Nov. 18 (*j*)	I.	Tr. Egr. First seen	E. Equat.	150	11 8 59		L.
18	I.	Bisection	,,	,,	11 13 4	11 13	,,
18	I.	Last contact	,,	,,	11 16 28		,,
27	I.	Tr. Egr. First seen	,,	220	7 23 57		L.
27	I.	Bisection	,,	,,	7 26 47	7 28	,,
27	I.	Last contact	,,	,,	7 29 36		,,
27	II.	Occ. D. First contact	,,	,,	7 44 21		,,
27	II.	Bisection	,,	,,	7 46 49	7 47	,,
27	II.	Last seen	,,	,,	7 48 37		,,
27 (*k*)	II.	Occ. D. First contact	Altaz.	100	7 47 45		T. H.
27	II.	Bisection	,,	,,	7 49 2	7 47	,,
27	II.	Last seen	,,	,,	7 50 27		,,
Dec. 3	I.	Ecl. R. First seen	E. Equat.	150	13 13 17	13 12 54	,,
6	II.	Tr. Egr. Last contact	,,	,,	7 42 39	7 41	A. C.
12	I.	Occ. D. First contact	Photo. Equat.	225	6 10 47		C. D.
12	I.	Bisection	,,	,,	6 12 2	6 12	,,
12	I.	Last seen	,,	,,	6 13 37		,,
13 (*l*)	II.	Tr. Ing. First contact	E. Equat.	150	7 31 30		C. M.
13	II.	Bisection	,,	,,	7 33 29	7 37	,,
13	II.	Last seen	,,	,,	7 36 12		,,
22	II.	Occ. R. First seen	,,	220	6 54 16		A. C.
22	II.	Last contact	,,	,,	6 56 5	6 56	,,

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1892 Dec. 22 (*m*)	II.	Ecl. D. Began to fade	E. Equat.	220	6 58 12	7 4 13	A. C.
22	II.	Last seen	,,	,,	7 2 23		,,
26 (*n*)	III.	Tr. Egr. First seen	,,	150	7 3 34	7 9	L.
26 (*o*)	III.	Last contact	,,	,,	7 11 23		,,
28 (*p*)	I.	Ecl. R. First seen	,,	220	7 59 22	7 58 24	,,
28	I.	Bisection	,,	,,	8 1 1		,,
28	I.	Full brightness	,,	,,	8 2 11		,,
29	II.	Occ. R. First seen	,,	150	9 28 43	9 29	T. H.
29	II.	Last contact	,,	,,	9 30 47		,,
29	II.	Ecl. D. Last seen	,,	,,	9 39 31	9 41 11	,,

Notes.

(*a*) A good observation. Definition very good. (*b*) Fairly good observation, but *Jupiter* was low down at the time.
(*c*) The satellite was first noticed at $12^h\ 45^m$. The first phase was lost owing to its reappearing so much earlier than was expected.
(*d*) A very good observation. (*e*) Not a good observation; *Jupiter* very low. (*f*) Satellite hung on the limb some time.
(*g*) The time noted is probably a little late. (*h*) Considered a good observation. (*i*) Not a good observation.
(*j*) Observation very rough. Satellite scarcely visible; thick fog. (*k*) Definition very bad; foggy.
(*l*) Satellite very faint; foggy. (*m*) Considered a fairly good observation. (*n*) A fairly good observation.
(*o*) Considered a very good observation. (*p*) Observations not of much value; foggy.

The initials H. T., C., L., H., A. C., B., T. H., C. M., C. D., R. C., and A. E. are those of Mr. Turner, Mr. Criswick, Mr. Lewis, Mr. Hollis, Mr. Crommelin, Mr. Bryant, Mr. Hudson, Mr. Martin, Mr. Davidson, Mr. Checseman, and Miss Everett respectively.

The aperture of the object glass of the East Equatoreal is 6·7 inches, and of the Altazimuth $3\frac{3}{4}$ inches. The abbreviation "Photo. Equat." denotes the guiding telescope of the Photographic Equatoreal, aperture 10 inches.

Observations of the Phenomena of Jupiter's Satellites at Bermerside Observatory, Halifax, in the year 1892. By Joseph Gledhill.

Day of Obs. 1892.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation. h m s	*N. Almanac* Time. h m s	Remarks.
Jan. 1	I.	Tr. I.	Ext. contact.	5 42 0	5 42	Poor definition.
			Int. contact.	5 44 30		
	I.	Sh. I.	Int. contact.	6 56 30	6 54	
Sept. 8	II.	Sh. I.	Int. contact.	10 33	10 27	Good definition.
	II.	Tr. I.	Ext. contact.	12 10 30	12 10	
			Bisection.	12 13		
			Int. contact.	12 15		
10	I.	Sh. I.	Int. contact.	9 18	9 16	Bad definition.
	II.	Oc. R.	Bisection.	9 25	9 25	
			Ext. contact.	9 27		
	I.	Tr. I.	Ext. contact.	10 6	10 4	
13	III.	Ec. D.	Fading?	11 34 30	11 38 13	Good definition.
			Fading.	11 36 30		
			Half gone.	11 38 30		
			Just gone.	11 40 47		
	III.	Ec. R.	First seen.	13 45 2	13 49 46	
			Half out.	13 48		
			Full brightness	13 53		
17	I.	Sh. I.	Int. contact.	11 11 30	11 10	Fair definition.
	II.	Oc. R.	Bisection.	11 40 30	11 41	
			Ext. contact.	11 41 30		
	I.	Tr. I.	Ext. contact.	11 48 30	11 49	
			Bisection.	11 50 30		
			Int. contact.	11 51 30		
24	III.	Tr. E.	Bisection.	9 35	9 42	Fair definition.
			Ext. contact.	9 43		
	II.	Ec. D.	Half gone.	10 33	10 35 1	
			Just gone.	10 35 15		
25	I.	Ec. D.	Fading?	10 15	10 18 11	
			Fading.	10 16		
			Half gone?	10 17		
			Just gone.	10 18 40		
26	I.	Tr. I.	Ext. contact.	7 58 30	7 59	
			Bisection.	8 0		
			Int. contact.	8 3		

Day of Obs. 1892.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation. h m s	*N. Almanac* Time. h m s	Remarks.
Sept. 26	II.	Tr. E.	Int. contact.	8 18	8 20	
			Bisection.	8 21		
			Ext. contact.	8 24		
	I.	Sh. E.	Int. contact.	9 45	9 46	
			Just off?	9 47 30		
Oct. 4	I.	Oc. R.	Bisection.	9 3	9 5	Cloudy.
			Ext. contact.	9 5		
10	II.	Sh. I.	First seen on disc.	10 18	10 18	
			Int. contact.	10 20		
	II.	Tr. I.	Int. contact.	10 29	10 27	Cloudy.
11	I.	Ec. D.	Fading?	8 30	8 37 5	Fair definition.
			Fading.	8 32		
			Half gone.	8 34		
			Contact with planet?	8 35		
			Just gone.	8 36 54		
	I.	Oc. R.	First seen.	10 46	10 49	
			Bisection.	10 48		
			Contact.	10 50		
17	II.	Tr. I.	Ext. contact.	12 38	12 42	Good definition.
			Bisection.	12 40		
			Int. contact.	12 42		
	II.	Sh. I.	First seen.	12 54	12 56	
			Bisection?	12 55		
			Int. contact.	12 57		
	I.	Tr. I.	Ext. contact.	13 7	13 8	
			Bisection.	13 9		
			Int. contact.	13 10 30		
	I.	Sh. I.	First seen.	13 16	13 16	
			Bisection.	13 17		
			Int. contact.	13 18 30		
18	I.	Oc. D.	Ext. contact.	10 20	10 21	Fair definition.
			Bisection.	10 22		
			Just gone.	10 22 15		
	I.	Ec. R.	First seen.	12 40 50	12 41 39	Fair definition.
			Half out?	12 43		
			Full brightness?	12 47		

Day of Obs. 1892.	Satel-lite.	Pheno-menon.	Phase.	G.M.T. of Observation. h m s	*N. Almanac* Time. h m s	Remarks.
Oct. 19	III.	Ec. R.	First seen.	9 51 10	9 53 46	The satellite would have been seen some seconds sooner but for cloud.
			Half out?	9 53		
			Fully out?	9 56		
	I.	Sh. E.	Int. contact.	9 57	9 58	
	II.	Ec. R.	First seen.	10 4 31	10 3 7	Bad sky to-night.
			Half out.	10 7 0		
			Fully out.	10 8 30		
25	I.	Oc. D.	Ext. contact.	12 3 30	12 5	Fair definition.
			Bisection.	12 5 30		
			Just gone.	12 7 15		
28	II.	Sh. E.	Int. contact.	7 24	7 26	Cloudy.
Nov. 3	I.	Oc. D.	Contact.	8 14	8 16	Very bad definition.
			Just gone.	8 17		
4	II.	Sh. E.	Int. contact.	10 1	10 5	Cloudy.
11	I.	Tr. I.	Ext. contact.	7 13 30	7 13	Fair definition.
			Bisection.	7 15 30		
			Int. contact.	7 17 0		
	I.	Sh. I.	First seen.	7 57 0	7 58	
			Bisected.	7 58 30		
			Int. contact.	8 0 0		
	II.	Tr. I.	Ext. contact.	8 38 30	8 44	
			Bisection.	8 41 30		
			Int. contact.	8 43 30		
	I.	Tr. E.	Int. contact.	9 23 0	9 26	
			Bisection.	9 25 0		
			Ext. contact.	9 26 0		
	II.	Sh. E.	Int. contact.	10 6 30	10 10	
			Bisection.	10 8 0		
29	II.	Sh. I.	Int. contact.	4 51	4 50	Stormy.
	II.	Tr. E.	Int. contact.	5 6	5 12	Stormy.
			Ext. contact.	5 11		
	II.	Sh. E.	Int. contact.	7 16	7 19	Stormy.
Dec. 1	III.	Oc. R.	Ext. contact.	5 40	5 45	Very cloudy.
	III.	Ec. D.	Fading?	8 1	8 5 52	Very cloudy.
			Half gone?	8 5		
			Just gone.	8 9 18		

Day of Obs. 1892.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation. h m s	*N. Almanac* Time. h m s	Remarks.
Dec. 6	II.	Tr. I.	Ext. contact.	5 4	5 8	Bad definition.
			Bisection?	5 6		
			Int. contact.	5 8		
	II.	Sh. I.	First seen.	7 27 30	7 30	
			Int. contact.	7 29 30		
	II.	Tr. E.	Int. contact.	7 34	7 41	
			Bisection?	7 36		
			Ext. contact.	7 37		
	II.	Sh. E.	Int. contact?	9 52	9 58	
12	I.	Oc. D.	Ext. contact.	6 11	6 12	Much cloud passing.
			Bisection?	6 13		
			Last seen.	6 14 30		
	I.	Ec. R.	First seen.	9 38 6	9 37 39	A bad night.
			Half out?	9 41 0		
			Full?	9 44 30		
13	I.	Sh. I.	First seen.	4 37 30	4 37	Strong twilight.
			Int. contact.	4 39		
	I.	Tr. E.	Int. contact.	5 34	5 36	Bad definition.
			Bisection.	5 35		
			Ext. contact.	5 37		
	I.	Sh. E.	Int. contact.	6 45	6 50	Bad definition.
	II.	Tr. I.	Ext. contact.	7 32	7 37	
			Bisection.	7 35		
			Int. contact.	7 36 30		
15	II.	Ec. R.	First seen.	6 50 10	6 49 12	Bad sky.
			Half out?	6 51 30		
			Full?	6 53		
	III.	Oc. D.	Ext. contact.	10 46	10 48	Planet low.
			Bisection.	10 49		Much motion.
			Just gone.	10 53		Poor definition.
26	III.	Tr. I.	Ext. contact.	4 44 40	4 42	Fair definition.
			Bisection?	4 50		
			Int. contact.	4 53		
	I.	Oc. D.	Ext. contact.	9 57	9 58	Much motion.
			Bisection.	9 59		
			Last seen.	10 1		
	III.	Sh. I.	First seen.	10 14 30	10 15	Bad definition.
			Int. contact.	10 18		

Day of Obs.	Satellite.	Phenomenon.	Phase.	G.M.T. of Observation.	*N. Almanac* Time.	Remarks.
1892.				h m s	h m s	
Dec. 27	I.	Tr. I.	Ext. contact.	7 9 30	7 7	Good definition.
			Bisection.	7 11 30		
			Int. contact.	7 12 30		
	I.	Sh. I.	First seen.	8 27	8 28	
			Int. contact.	8 30		
	I.	Tr. E.	Int. contact.	9 18	9 21	Definition not good.
			Bisection.	9 20		
			Ext. contact.	9 22 30		
28	I.	Ec. R.	First seen.	7 58 44	7 58 24	Some cloud.

Instrument: The $9\frac{1}{3}$ inch Cooke equatoreal refractor; power 240.

January 1.—Satellite I. was invisible at $6\frac{1}{2}^h$; was a little brighter than the limb of *Jupiter* at ingress.

September 8.—Satellite II. much brighter than limb of planet at ingress; its shadow was black all through its transit.

"Red Spot" exceedingly faint; preceding end central at $10^h \pm$; following end central at $10^h\ 35^m \pm$. Dark and bright spots on the belts.

September 10.—Satellite I. brighter than limb of *Jupiter* at ingress.

September 13.—"Red Spot" very faint and difficult to see.

September 24.—Satellite III. was visible throughout transit. A small bright circular spot, like a satellite in transit, was seen on the southern edge of the "Red Spot" zone; central about $9^h\ 30^m$.

September 26.—At $8^h\ 30^m$ Satellite I. was invisible on disc. At $9^h\ 40^m$ it was still invisible.

October 11.—Satellite I. much brighter than the adjacent limb of *Jupiter* at reappearance.

October 17.—Satellite II. much brighter than the limb when it passed on to the disc; soon grew faint; quite invisible half an hour after ingress.

Satellite I. very much brighter than the limb at ingress.

November 11.—Satellite I. brighter than the limb of *Jupiter* at ingress; invisible at 8^h and 9^h and till $9^h\ 15^m$.

Satellite II. much brighter than the limb of the planet at ingress; visible at 9^h; invisible at $9^h\ 15^m$.

November 29.—Satellite II. was invisible at $4^h\ 30^m$ and $4^h\ 50^m$.

December 6.—Satellite II. was invisible at 6^h and at 7^h.

December 13.—Satellite I. invisible from 4^h till $5^h\ 25^m$ during its transit.

Note on the Red Spot on Jupiter. By Joseph Gledhill.

This well-known object was carefully looked for as soon as the planet came into a good position for observation.

1892 July.—Could never obtain a view of the whole outline of the spot. No trace of colour.

August.—At moments of best definition portions of the outline were with difficulty seen.

September.—The preceding and following ends were glimpsed, but never the whole. On the 8th it was on the central meridian about $10^h\ 15^m$, but the observation was necessarily very uncertain.

September 13.—Red Spot very faint, but most of the outline was seen.

October.—A very difficult object; no colour; the ends were occasionally fairly seen.

November.—On the 10th it was probably on the central meridian about $8^h\ 15^m$; it was a mere glimmer of an outline, and seen only at best moments.

December 6.—The Red Spot was central about $9^h\ 55^m$; it was seen with great difficulty; perhaps the whole outline was seen at best moments, and there was also a slight tinge of warm colour. The time of central transit was therefore very difficult to observe.

Bermerside Observatory, Halifax.

Observations of the Phenomena of the Satellites of Saturn at Bermerside Observatory, Halifax, in the year 1892. By Joseph Gledhill.

Instrument, the 9½ inch Cooke equatoreal refractor; powers 240 and 300.

These very difficult observations were begun in January, but, owing to cloudy weather and bad definition, no results worth recording were obtained till April; and it was soon very evident that the refractor was hardly capable of dealing with these phenomena.

April 4.—*Dione* E elongation. Difficult. In line at $8^h{\cdot}55$? Past at $9^h{\cdot}10$. *Enceladus* invisible.

April 8.—Moon not far from *Saturn*. *Tethys* not seen at 7^h when at E elongation.

Rhea θ. Not up at $8^h{\cdot}20$. Past at $8^h{\cdot}30$. Cloudy after 10^h.

April 9.—*Dione* ϵ. Seen with great difficulty. Moon very near *Saturn*. On tangent to end of ring (E) between $7^h{\cdot}50$ and $7^h{\cdot}55$.

April 10.—Cloudless. *Saturn* very beautifully seen.

Dione ζ. The satellite easily seen at $8^h{\cdot}40$, but as it got near the ring it became a difficult object. It was not on the tangent

at $8^h{\cdot}50$; on at $8^h{\cdot}55$? Certainly on at or just before 9^h. Could not see it distinctly after 9^h. Very strong moonlight. Could not see the satellite at all at 10^h and 11^h.

April 11.—*Tethys* θ. Cloudless. Satellite very near the end of the ring at $10^h{\cdot}50$. At 11^h satellite lost in the ring.

Tethys δ. At 12^h and up to $12^h{\cdot}50$ satellite could not be seen.

April 25.—Clear; good definition. *Dione* θ. Satellite quite bright. Difficult at $9^h{\cdot}30$ owing to its being so near the ring. Last seen at 10^h, when it was not quite on the tangent line. Cloudy after 11^h.

April 28.—Definition not good. *Titan* γ at $7^h{\cdot}2$ not seen. Nor *Enc.* η at $8^h{\cdot}4$.

Dione on reappearance from eclipse at $9^h{\cdot}9$ not seen.

Tethys θ. At $10^h{\cdot}6$ not seen.

Titan η. On tangent at $10^h{\cdot}9$ nearly? On at 11^h? Just past at $11^h{\cdot}5$? Past at $11^h{\cdot}10$.

April 29.—Good definition. *Tethys* ζ. Not up at $9^h{\cdot}12$. On line between $9^h{\cdot}15$ and $9^h{\cdot}20$.

Enceladus is now well seen, but it could not be seen when it got near the ring.

Tethys β. Could not see it when near the ball of the planet. *Dione* ζ. Definition bad. On the tangent line about $12^h{\cdot}40$.

April 30.—Good definition. *Enc.* ϵ. Satellite just visible. Thought it was on the tangent line about $9^h{\cdot}40$.

Tethys δ. It became invisible at $9^h{\cdot}54$ owing to its closeness to the ring.

May 1.—Good definition; some haze. *Tethys* β $8^h{\cdot}5$. Very difficult; lost sight of it at $8^h{\cdot}25$, when it was probably on the tangent line.

Tethys Sh. $10^h{\cdot}4$. Began to look for this at 9^h, and continued the watch till $10^h{\cdot}5$, but never saw it.

Tethys γ. Not seen.

May 10.—*Tethys* E. Not up at 9^h; up between $9^h{\cdot}5$ and $9^h{\cdot}10$.

May 14.— *Titan* η. Not quite on line at $9^h{\cdot}10$. Cloudy.

May 15.—Windy; often much cloud. *Dione* E. $9^h{\cdot}50$, not up; $9^h{\cdot}55$, up? 10^h, up? $10^h{\cdot}5$ past.

Tethys θ. Not on line at $10^h{\cdot}20$; very near ring at $10^h{\cdot}25$; lost in ring at $10^h{\cdot}30$.

May 18.—*Tethys* Sh. Watched for it from 8^h till 11^h; not seen. Planet getting low.

June 1.—Often cloudy. *Enc.* ζ $8^h{\cdot}2$; not seen.

Dione ζ, $8^h{\cdot}8$; on tangent at $8^h{\cdot}45$; not up at $8^h{\cdot}40$.

Tethys θ. Not up at $9^h{\cdot}55$. Last seen at 10^h, and it was not quite on the line then.

Dione β, $11^h{\cdot}1$; not seen; planet too low.

Ephemeris of Juno, near the time of Opposition, 1893; computed from the Corrected Elements published in "Monthly Notices," vol. l. p. 495.

(*Communicated by the Superintendent of the "Nautical Almanac."*)

At transit at Greenwich.

Date.	Apparent Right Ascension.			Apparent Declination.				Date.	Apparent Right Ascension.			Apparent Declination.			
	h	m	s		°	′	″		h	m	s		°	′	″
Jan. 7	10	8	27·99	S.	0	11	53·1	Feb. 8	9	48	4·40	N.	3	17	26·7
8	10	8	9·88		0	8	58·8	9	9	47	13·34		3	27	3·9
9	10	7	50·14		0	5	49·5	10	9	46	22·19		3	36	47·4
10	10	7	28·78	S.	0	2	24·9	11	9	45	31·02		3	46	36·7
11	10	7	5·82	N.	0	1	14·9	12	9	44	39·91		3	56	31·3
12	10	6	41·28		0	5	10·0	13	9	43	48·93		4	6	30·7
13	10	6	15·18		0	9	20·3	14	9	42	58·13		4	16	34·2
14	10	5	47·55		0	13	45·9	15	9	42	7·61		4	26	41·0
15	10	5	18·42		0	18	26·6	16	9	41	17·43		4	36	50·8
16	10	4	47·82		0	23	22·4	17	9	40	27·66		4	47	2·9
17	10	4	15·78		0	28	33·1	18	9	39	38·37		4	57	16·7
18	10	3	42·33		0	33	58·7	19	9	38	49·62		5	7	31·5
19	10	3	7·53		0	39	39·0	20	9	38	1·48		5	17	46·9
20	10	2	31·42		0	45	33·9	21	9	37	14·02		5	28	2·2
21	10	1	54·04		0	51	43·0	22	9	36	27·30		5	38	16·9
22	10	1	15·43		0	58	6·3	23	9	35	41·36		5	48	30·4
23	10	0	35·66		1	4	43·3	24	9	34	56·26		5	58	42·2
24	9	59	54·76		1	11	34·0	25	9	34	12·08		6	8	51·8
25	9	59	12·78		1	18	38·0	26	9	33	28·85		6	18	58·6
26	9	58	29·80		1	25	55·0	27	9	32	46·62		6	29	2·1
27	9	57	45·86		1	33	24·6	28	9	32	5·43		6	39	2·0
28	9	57	1·00		1	41	6·4	Mar. 1	9	31	25·34		6	48	57·7
29	9	56	15·27		1	49	0·3	2	9	30	46·39		6	58	48·9
30	9	55	28·75		1	57	5·8	3	9	30	8·61		7	8	35·0
31	9	54	41·51		2	5	22·5	4	9	29	32·04		7	18	15·7
Feb. 1	9	53	53·58		2	13	49·9	5	9	28	56·72		7	27	50·6
2	9	53	5·04		2	22	27·8	6	9	28	22·68		7	37	19·3
3	9	52	15·94		2	31	15·5	7	9	27	49·95		7	46	41·4
4	9	51	26·36		2	40	12·8	8	9	27	18·56		7	55	56·6
5	9	50	36·35		2	49	19·0	9	9	26	48·54		8	5	4·7
6	9	49	45·98		2	58	33·7	10	9	26	19·92		8	14	5·3
7	9	48	55·30	N.	3	7	56·5	11	9	25	52·72	N.	8	22	58·1

Date.	Apparent Right Ascension.	Apparent Declination.	Date.	Apparent Right Ascension.	Apparent Declination.
	h m s	° ′ ″		h m s	° ′ ″
Mar. 12	9 25 26·97	N. 8 31 42·8	Apr. 15	9 25 56·60	N. 11 51 53·0
13	9 25 2·69	8 40 19·2	16	9 26 22·58	11 54 48·1
14	9 24 39·89	8 48 47·0	17	9 26 49·84	11 57 33·5
15	9 24 18·62	8 57 6·0	18	9 27 18·34	12 0 9·2
16	9 23 58·87	9 5 15·8	19	9 27 48·07	12 2 35·2
17	9 23 40·65	9 13 16·3	20	9 28 19·01	12 4 51·8
18	9 23 23·99	9 21 7·5	21	9 28 51·14	12 6 58·9
19	9 23 8·88	9 28 49·0	22	9 29 24·43	12 8 56·7
20	9 22 55·34	9 36 20·7	23	9 29 58·87	12 10 45·2
21	9 22 43·39	9 43 42·5	24	9 30 34·42	12 12 24·6
22	9 22 33·01	9 50 54·1	25	9 31 11·09	12 13 54·9
23	9 22 24·20	9 57 55·6	26	9 31 48·84	12 15 16·3
24	9 22 16·97	10 4 46·9	27	9 32 27·64	12 16 28·8
25	9 22 11·30	10 11 27·9	28	9 33 7·48	12 17 32·6
26	9 22 7·20	10 17 58·5	29	9 33 48·35	12 18 27·8
27	9 22 4·66	10 24 18·8	30	9 34 30·22	12 19 14·5
28	9 22 3·67	10 30 28·6	May 1	9 35 13·06	12 19 52·7
29	9 22 4·22	10 36 27·9	2	9 35 56·86	12 20 22·6
30	9 22 6·29	10 42 16·7	3	9 36 41·60	12 20 44·2
31	9 22 9·88	10 47 55·2	4	9 37 27·27	12 20 57·7
Apr. 1	9 22 14·97	10 53 23·2	5	9 38 13·85	12 21 3·1
2	9 22 21·55	10 58 40·8	6	9 39 1·32	12 21 0·5
3	9 22 29·60	11 3 47·9	7	9 39 49·67	12 20 50·0
4	9 22 39·12	11 8 44·7	8	9 40 38·87	12 20 31·7
5	9 22 50·10	11 13 31·0	9	9 41 28·91	12 20 5·6
6	9 23 2·52	11 18 7·0	10	9 42 19·79	12 19 32·0
7	9 23 16·36	11 22 32·7	11	9 43 11·48	12 18 50·8
8	9 23 31·61	11 26 48·2	12	9 44 3·97	12 18 2·0
9	9 23 48·25	11 30 53·4	13	9 44 57·23	12 17 5·8
10	9 24 6·28	11 34 48·5	14	9 45 51·27	12 16 2·4
11	9 24 25·67	11 38 33·4	15	9 46 46·06	12 14 51·7
12	9 24 46·41	11 42 8·3	16	9 47 41·58	12 13 33·9
13	9 25 8·50	11 45 33·1	17	9 48 37·83	N. 12 12 9·0
14	9 25 31·90	N. 11 48 48·0			

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1893 *January* 5.

Ephemerides of the Five Inner Satellites of Saturn, 1893.

By A. Marth.

The results of the measures which may have been made during last year's important apparition of *Saturn* not being yet available, the present ephemerides are founded upon the same elements, except that of the longitude of the central meridian.

In the following tables P denotes the position-angle of the axis of *Saturn*; L + 180° the planetocentric longitude of the Earth referred to the assumed fundamental plane; Λ + 180° that of the Sun, or Λ − L the difference between the two. B and *B* denote the planetocentric latitude of the Earth and Sun above the fundamental plane.

Mr. A. S. Williams's observations of a series of surface markings indicate that their rate of motion has varied considerably from that of the preceding year, and that for the present the identification of the various markings is quite doubtful. Nevertheless, I have thought it better not to fail to give facilities to observers by furnishing in the last column the longitude of *Saturn's* central meridian corresponding to the motion of the most frequently observed markings. The adopted daily rate of rotation is 844°·80, corresponding to a period of $10^h\ 13^m{\cdot}64$.

Greenwich Noon 1893.		P	L	B	*B*	A−L	Long. of ♄'s Central Mer.	Diff.
		°	°	°	°	°	°	°
Feb.	15	357·183	192·009	+8·802	+7·128	−3·899	34·22	4224·40
	20	·161	191·806	8·684	7·200	3·546	298·62	·41
	25	·135	191·570	8·551	7·272	3·160	203·03	·42
Mar.	2	·106	191·306	8·407	7·344	2·745	107·45	·42
	7	·074	191·017	8·253	7·416	2·305	11·87	·42
	12	·040	190·706	8·090	7·488	1·844	276·29	·41
	17	357·005	190·378	7·921	7·560	1·366	180·70	·39
	22	356·968	190·037	7·748	7·631	0·875	85·09	·38
	27	·930	189·689	7·573	7·703	−0·376	349·47	·35
Apr.	1	·892	189·338	7·399	7·775	+0·126	253·82	·32
	6	·855	188·988	7·228	7·846	0·626	158·14	·29
	11	·818	188·645	7·062	7·918	1·120	62·43	·25
	16	·782	188·312	6·904	7·989	1·603	326·68	·21
	21	·748	187·995	6·755	8·061	2·071	230·89	·17
	26	·716	187·697	6·617	8·132	2·520	135·06	·12
May	1	356·687	187·421	6·493	8·203	2·946	39·18	·07
	6	·660	187·172	6·384	8·274	3·346	303·25	4224·02
	11	·637	186·952	6·290	8·345	3·717	207·27	4223·98
	16	·617	186·763	6·214	8·416	4·056	111·25	·93
	21	·601	186·608	6·156	8·487	4·362	15·18	·87
	26	·588	186·488	6·116	8·557	4·633	279·05	·82
	31	·579	186·404	6·095	8·628	4·868	182·87	·78
June	5	356·574	186·357	6·093	8·699	5·065	86·65	·73
	10	·573	186·348	6·110	8·769	5·225	350·38	·68
	15	·576	186·376	6·147	8·839	5·347	254·06	·64
	20	·583	186·442	6·203	8·909	5·432	157·70	·61
	25	·594	186·546	6·277	8·980	5·479	61·31	·57
	30	·608	186·686	6·369	9·050	5·490	324·88	·53
July	5	·627	186·861	6·478	9·120	5·466	228·41	·50
	10	·649	187·071	6·604	9·190	5·407	131·91	4223·47
	15	356·675	187·314	+6·745	+9·260	+5·314	35·38	

In the tables for the five inner satellites, a and b denote the semi-axis of the apparent orbits, $l-\mathrm{L}$ the orbital longitudes reckoned from the points which are in superior conjunction with the planet's centre or in opposition to the Earth in longitude. By adding to $l-\mathrm{L}$ the value of L from the preceding table, the longitudes l are found, which are corrected for the equation of light.

Greenwich Noon.	Semidiameter of Ball. Equat.	Phase.	Polar.	Semiaxis of Ring. Major.	Minor.	*Mimas.* a_1	b_1	l_1-L	Diff.
1893.	″	″	″	″	″	″	″	°	°
Feb. 15	9·19	0·021	8·32	21·19	3·24	28·96	+4·43	93·41	1910·34
20	9·25	·018	8·36	21·33	3·22	29·15	4·40	203·75	·36
25	9·31	·014	8·41	21·45	3·19	29·31	4·36	314·11	·38
Mar. 2	9·35	·011	8·45	21·56	3·15	29·46	4·31	64·49	·39
7	9·39	·008	8·49	21·65	3·11	29·59	4·25	174·88	·39
12	9·43	·005	8·52	21·73	3·06	29·69	4·18	285·27	·39
17	9·45	·003	8·54	21·78	3·00	29·77	4·10	35·66	·39
22	9·47	·001	8·55	21·82	2·94	29·82	4·02	146·05	·38
27	9·48	·000	8·56	21·84	2·88	29·85	3·93	256·43	·37
Apr. 1	9·48	·000	8·56	21·84	2·82	29·85	3·84	6·80	·34
6	9·47	·000	8·55	21·82	2·75	29·82	3·75	117·14	·33
11	9·45	·002	8·53	21·78	2·68	29·77	3·66	227·47	·30
16	9·42	·004	8·51	21·73	2·61	29·69	3·57	337·77	·27
21	9·39	·006	8·48	21·65	2·55	29·58	3·48	88·04	·23
26	9·35	·009	8·45	21·56	2·49	29·46	3·40	198·27	·19
May 1	9·30	·013	8·41	21·45	2·43	29·31	3·32	308·46	·16
6	9·25	·016	8·36	21·33	2·37	29·14	3·24	58·62	·11
11	9·19	·019	8·31	21·20	2·32	28·96	3·17	168·73	·07
16	9·13	·023	8·25	21·05	2·28	28·77	3·11	278·80	1910·03
21	9·07	·026	8·19	20·90	2·24	28·56	3·06	28·83	1909·98
26	9·00	·029	8·12	20·74	2·21	28·34	3·02	138·81	·94
31	8·92	·032	8·06	20·57	2·19	28·11	2·99	248·75	·90
June 5	8·85	·034	7·99	20·40	2·17	27·88	2·96	358·65	·85
10	8·77	·036	7·92	20·23	2·16	27·64	2·94	108·50	·81
15	8·70	·038	7·86	20·05	2·15	27·40	2·93	218·31	·77
20	8·62	·039	7·79	19·88	2·15	27·16	2·93	328·08	·73
25	8·55	·039	7·72	19·71	2·15	26·93	2·94	77·81	·70
30	8·47	·038	7·65	19·54	2·17	26·70	2·96	187·51	·66
July 5	8·40	·038	7·59	19·37	2·19	26·47	2·99	297·17	·62
10	8·33	·037	7·53	19·21	2·21	26·24	3·02	47·79	1909·60
15	8·26	0·035	7·46	19·05	2·24	26·03	+3·06	156·39	

Greenwich Noon. 1893.	*Enceladus* a_s	b_s	l_s-L	Diff.	*Tethys.* a_s	b_s	l_s-L	Diff.
	″	″	°	°	″	″	°	°
Feb. 15	37·15	+5·69	46·73	1313·95	45·99	+7·04	306·26	953·75
20	37·39	5·64	280·68	·97	46·28	6·99	180·01	·78
25	37·60	5·59	154·65	1313·99	46·55	6·92	53·79	·80
Mar. 2	37·79	5·53	28·64	1314·00	46·79	6·84	287·59	·82
7	37·96	5·45	262·64	·02	46·99	6·74	161·41	·83
12	38·09	5·36	136·66	·02	47·15	6·63	35·24	·84
17	38·19	5·26	10·68	·02	47·27	6·51	269·08	·84
22	38·26	5·16	244·70	·02	47·36	6·38	142·92	·84
27	38·29	5·05	118·72	·01	47·40	6·25	16·76	·84
Apr. 1	38·29	4·93	352·73	1314·00	47·40	6·11	250·60	·83
6	38·25	4·81	226·73	1313·98	47·35	5·96	124·43	·81
11	38·18	4·69	100·71	·96	47·27	5·81	358·24	·80
16	38·08	4·58	334·67	·93	47·14	5·67	232·04	·77
21	37·95	4·47	208·60	·90	46·98	5·53	105·81	·75
26	37·79	4·36	82·50	·87	46·78	5·39	339·56	·71
May 1	37·60	4·26	316·37	·83	46·55	5·26	213·27	·68
6	37·39	4·16	190·20	·80	46·28	5·15	86·95	·65
11	37·16	4·07	64·00	·76	45·99	5·04	320·60	·61
16	36·90	3·99	297·76	·72	45·68	4·94	194·21	·57
21	36·63	3·93	171·48	·67	45·35	4·86	67·78	·53
26	36·35	3·87	45·15	·63	45·00	4·79	301·31	·49
31	36·06	3·83	278·78	·59	44·64	4·74	174·80	·45
June 5	35·76	3·80	152·37	·55	44·27	4·70	48·25	·41
10	35·46	3·78	26·92	·51	43·89	4·67	281·66	·37
15	35·15	3·76	259·43	·47	43·52	4·66	155·03	·33
20	34·85	3·77	132·90	·43	43·14	4·66	29·36	·30
25	34·55	3·78	6·33	·39	42·76	4·68	261·66	·26
30	34·25	3·80	239·72	·36	42·39	4·71	134·92	·22
July 5	33·95	3·83	113·08	·33	42·03	4·74	8·14	·19
10	33·67	3·87	346·41	1313·29	41·68	4·79	241·33	953·15
15	33·39	+3·92	219·70		41·34	+4·85	114·48	

Greenwich Noon. 1893.	*Dione.* a_4	b_4	l_4-L	Diff.	*Rhea.* a_5	b_5	l_5-L	Diff.
	″	″	°	°	″	″	°	°
Feb. 15	58·90	+9·01	321·28	657·92	82·26	+12·59	44·34	398·68
20	59·28	8·95	259·20	·95	82·78	12·50	83·02	·71
25	59·62	8·86	197·15	·97	83·26	12·38	121·73	·73
Mar. 2	59·92	8·76	135·12	657·99	83·68	12·23	160·46	·76
7	60·18	8·64	73·11	658·01	84·04	12·06	199·22	·77
12	60·39	8·50	11·12	·02	84·33	11·86	237·99	·79
17	60·55	8·34	309·14	·03	84·55	11·65	276·78	·80
22	60·65	8·17	247·17	·02	84·70	11·42	315·58	·80
27	60·71	8·00	185·19	·03	84·78	11·17	354·38	·80
Apr. 1	60·71	7·82	123·22	·02	84·78	10·92	33·18	·80
6	60·65	7·63	61·24	658·01	84·70	10·66	71·98	·79
11	60·54	7·44	359·25	657·99	84·55	10·40	110·77	·77
16	60·38	7·26	297·24	·97	84·32	10·14	149·54	·76
21	60·17	7·08	235·21	·94	84·03	9·89	188·30	·73
26	59·92	6·91	173·15	·92	83·67	9·64	227·03	·70
May 1	59·62	6·74	111·07	·88	83·25	9·41	265·73	·68
6	59·28	6·59	48·95	·85	82·78	9·20	304·41	·64
11	58·91	6·45	346·80	·82	82·27	9·01	343·05	·61
16	58·51	6·33	284·62	·78	81·71	8·84	21·66	·58
21	58·08	6·23	222·40	·75	81·11	8·70	60·24	·54
26	57·63	6·14	160·15	·70	80·49	8·58	98·78	·50
31	57·17	6·07	97·85	·66	79·84	8·48	37·28	·46
June 5	56·70	6·02	35·51	·63	79·18	8·40	175·74	·42
10	56·22	5·99	333·14	·58	78·51	8·35	214·16	·39
15	55·73	5·97	270·72	·55	77·83	8·33	252·55	·35
20	55·25	5·97	208·27	·51	77·15	8·34	290·90	·31
25	54·77	5·99	145·78	·47	76·48	8·36	329·21	·27
30	54·29	6·02	83·25	·44	75·82	8·41	7·48	·23
July 5	53·83	6·07	20·69	·39	75·17	8·48	45·71	·20
10	53·38	6·14	318·08	657·36	74·54	8·57	83·91	398·18
15	52·94	+6·22	255·44		73·93	+8·68	112·09	

These values are to be interpolated for the times for which the apparent places of the satellites are required, when the position-angles p and distances s, or the rectangular coordinates x and y referred to the axes of the ball of *Saturn*, are found by means of the formulæ

$$s \sin (p-\mathrm{P}) = x = a \sin (l-\mathrm{L})$$
$$s \cos (p-\mathrm{P}) = y = b \cos (l-\mathrm{L}).$$

The adopted zero-meridian will pass the middle of the illuminated disc of *Saturn* at the following Greenwich mean times :—

1893.	h	m	h	m	1893	h	m	h	m
Feb. 15	9	15·3	19	28·8	Mar. 24	0	42·9	10	56·4
16	5	42·4	15	56·0	25	7	23·6	17	37·2
17	12	23·1	22	36·7	26	3	50·7	14	4·3
18	8	50·3	19	3·9	27	10	31·5	20	45·1
19	5	17·5	15	31·0	28	6	58·7	17	12·2
20	11	58·2	22	11·8	29	3	25·8	13	39·4
21	8	25·3	18	38·9	30	10	6·6	20	20·2
22	4	52·5	15	6·1	31	6	33·8	16	47·4
23	11	23·2	21	46·8	Apr. 1	3	1·0	13	14·6
24	8	0·4	18	14·0	2	9	41·7	19	55·3
25	4	27·5	14	41·1	3	6	8·9	16	22·5
26	11	8·3	21	21·8	4	2	36·1	12	49·7
27	7	35·4	17	49·0	5	9	16·9	19	30·5
28	4	2·6	14	16·1	6	5	44·0	15	57·6
Mar. 1	10	43·3	20	56·9	7	2	11·2	12	24·8
2	7	10·4	17	24·0	8	8	52·0	19	5·6
3	3	37·6	13	51·2	9	5	19·2	15	32·8
4	10	18·3	20	31·9	10	1	46·4	12	0·0
5	6	45·4	16	59·0	11	8	27·2	18	40·8
6	3	12·6	13	26·2	12	4	54·4	15	8·0
7	9	53·3	20	6·9	13	1	21·6	11	35·2
8	6	20·5	16	34·1	14	8	2·4	18	16·0
9	2	47·7	13	1·2	15	4	29·6	14	43·2
10	9	28·4	19	42·0	16	11	10·4	21	24·0
11	5	55·5	16	9·1	17	7	37·6	17	51·2
12	2	22·7	12	36·3	18	4	4·8	14	18·4
13	9	3·4	19	17·0	19	10	45·6	20	59·2
14	5	30·5	15	44·1	20	7	12·9	17	26·5
15	1	57·7	12	11·3	21	3	40·1	13	53·7
16	8	38·4	18	52·0	22	10	20·9	20	34·5
17	5	5·6	15	19·2	23	6	48·1	17	1·7
18	1	32·8	11	46·3	24	3	15·3	13	29·0
19	8	13·5	18	27·1	25	9	56·2	20	9·8
20	4	40·6	14	54·2	26	6	23·4	16	37·0
21	1	7·8	11	21·4	27	2	50·6	13	4·3
22	7	48·5	18	2·1	28	9	31·5	19	45·1
23	4	15·7	14	29·3	29	5	58·7	16	12·4

1893.	h m	h m	1893.	h m	h m
Apr. 30	2 26·0	12 39·6	June 1	1 29·3	11 42·9
May 1	9 6·8	19 20·5	2	8 10·3	18 23·9
2	5 34·1	15 47·7	3	4 37·6	14 51·3
3	2 1·3	12 14·9	4	1 4·9	11 18·6
4	8 42·2	18 55·8	5	7 46·0	17 59·6
5	5 9·5	15 23·1	6	4 13·3	14 27·0
6	1 36·7	11 50·4	7	0 40·7	10 54·4
7	8 17·6	18 31·2	8	7 21·7	17 35·4
8	4 44·9	14 58·5	9	3 49·1	14 2·8
9	1 12·1	11 25·8	10	10 30·1	20 43·8
10	7 53·0	18 6·7	11	6 57·5	17 11·2
11	4 20·3	14 34·0	12	3 24·8	13 38·5
12	0 47·6	11 1·2	13	10 5·9	20 19·6
13	7 28·5	17 42·2	14	6 33·2	16 46·9
14	3 55·8	14 9·4	15	3 0·6	13 14·3
15	10 36·7	20 50·4	16	9 41·7	19 55·4
16	7 4·0	17 17·7	17	6 9·0	16 22·7
17	3 31·3	13 45·0	18	2 36·4	12 50·1
18	10 12·3	20 25·9	19	9 17·5	19 31·2
19	6 39·6	16 53·2	20	5 44·9	15 58·6
20	3 5·9	13 19·5	21	2 12·3	12 25·9
21	9 46·8	20 0·5	22	8 53·3	19 7·0
22	6 14·1	16 27·8	23	5 20·7	15 34·4
23	2 41·4	12 55·1	24	1 48·1	12 1·8
24	9 22·4	19 36·0	25	8 29·2	18 42·9
25	5 49·7	16 3·3	26	4 56·6	15 10·3
26	2 18·0	12 31·6	27	1 24·0	11 37·7
27	8 59·0	19 12·6	28	8 5·1	18 18·8
28	5 26·3	15 39·9	29	4 32·5	14 46·2
29	1 53·6	12 7·3	30	0 59·9	11 13·6
30	8 34·6	18 48·2	July 1	7 41·0	17 54·7
31	5 1·9	15 15·6	2	4 8·4	14 22·1

In order to reduce the longitudes of the central meridian in the ephemeris for 1891–92 to the system here adopted, the longitudes require the corrections—

1891	Oct. 20	+ 60°	1892	Feb. 17	+ 180°
	Nov. 19	90		Mar. 18	210
	Dec. 19	120		Apr. 17	240
1892	Jan. 18	150		May 17	270
	Feb. 17	+ 180		June 16	+ 300

The rate of rotation adopted in last year's ephemeris was founded upon the observations of Mr. A. S. Williams, made in 1891 May and June, and the corresponding longitudes of several spots are given on p. 61 of vol. lii. In order to reduce these longitudes of spots to the system of the present ephemeris, the following angles must be added:—

1891 May	7	+106°	June	6	+ 76°
	17	96		16	66
	27	+ 86		26	+ 56

In the following list of approximate Greenwich mean times of conjunctions (reckoned parallel to the polar axis of the ball) of the satellites with the end points of the equatorial diameter of the ball and with those of the ring, the letters α, β, γ, δ denote the positions of the satellites when they are in conjunction with the end points of the equator in the order "north following, south following, south preceding, and north preceding," and ϵ, ζ, η, θ the corresponding positions at the end points of the ring. "Sup." and "inf." denote the observable superior and inferior conjunctions with the centre of the ball or the passage across the direction of the polar axis. In the case of *Rhea* and *Dione* the times of "e" and "w," the greatest eastern and western elongations, are added.

The present apparition of *Saturn* is the last for more than a dozen years which affords sufficiently favourable opportunities to observers with powerful instruments to contribute to our better knowledge of *Saturn's* system by careful estimations of the times of the predicted conjunctions; *v.* vol. lii. p. 191. It would be a pity and a cause of just reproach if the opportunities were again neglected.

G.M.T.			G.M.T.			G.M.T.		
1893.	h		1893.	h		1893.	h	
Feb. 11	12·7	En. η	Feb. 13	16·6	Mi. θ	Feb. 16	12·0	Di. ζ
	13·6	Te. α		18·4	Di. ζ		12·3	Rh. ζ
	13·9	Mi. η	14	8·7	Rh. δ		12·4	Mi. θ
	15·6	Te. ϵ		9·6	Te. γ		14·2	Di. β
	21·0	Di. w		9·8	Mi. η		14·9	Rh. β
12	9·0	Rh. η		10·6	Rh. sup.		15·9	Di. inf.
	9·4	Te. β		11·6	Te. η		16·8	Rh. inf.
	9·5	Di. θ		12·6	Rh. α		17·5	Di. γ
	11·8	Di. δ		14·6	Di. w		17·9	En. ζ
	12·3	Te. γ		15·1	Rh. ϵ		18·3	Mi. ϵ
	12·6	Mi. η		15·2	Mi. θ		18·8	Rh. γ
	14·3	Te. η		16·6	En. θ	17	8·3	Di. w
	15·0	Di. α	15	9·0	En. ζ		10·3	En. θ
	15·2	En. ζ		10·4	Te. ϵ		11·0	Mi. θ
	17·2	Di. ϵ		10·9	Di. ϵ		16·7	En. ϵ
13	10·9	Te. α		13·7	Rh. e		16·9	Mi. ϵ
	11·2	Mi. η		13·8	Mi. θ		19·9	Rh. w
	12·9	Te. ϵ		15·3	En. η	18	9·1	En. η
	14·0	En. ϵ	16	8·9	Te. η		9·6	Mi. θ

1893.	G.M.T. h		1893.	G.M.T. h		1893.	G.M.T. h	
Feb.	18	15·5 Mi. ϵ	Feb.	24	12·6 Mi. ζ	Feb.	28	15·7 En. ϵ
		17·1 Di. e			13·0 En. ϵ			18·4 Mi. θ
		18·5 Rh. θ			13·8 Te. θ			19·5 Di. θ
		19·2 En. θ			14·4 Rh. e			21·7 Di. δ
		20·9 Mi. ζ			15·8 Te. δ	Mar.	1	9·0 Te. β
		21·1 Rh. δ			17·0 Di. ζ			11·6 Mi. η
		21·9 Te. θ			18·5 Mi. η			11·9 Te. γ
	19	9·5 Di. inf.			18·7 Te. α			13·9 Te. η
		11·2 Di. γ			19·2 Di. β			15·8 Di. e
		11·6 En. ζ			20·7 Te. ϵ			17·0 Mi. θ
		13·4 Di. η			20·9 Di. inf.			18·2 En. θ
		14·2 Mi. ϵ			22·4 Di. γ		2	8·2 Di. inf.
		18·0 En. η		25	11·2 Mi. ζ			9·8 Di. γ
		19·6 Mi. ζ			12·4 Te. ζ			10·2 Mi. η
		20·5 Te. ζ			13·0 Rh. ζ			10·4 Rh. η
		22·5 Te. β			13·2 Di. w			10·6 Te. α
	20	10·4 En. ϵ			14·4 Te. β			10·6 En. ζ
		12·8 Mi. ϵ			15·6 En. θ			12·0 Di. η
		14·5 Di. θ			15·6 Rh. β			12·6 Te. ϵ
		16·7 Di. δ			17·1 Mi. η			15·6 Mi. θ
		18·2 Mi. ζ			17·3 Te. γ			17·0 En. η
		19·2 Te. θ			17·5 Rh. inf.			21·5 Mi. ϵ
		20·0 Di. α			19·3 Te. η		3	9·0 Rh. w
		20·5 En. ζ			19·5 Rh. γ			9·2 Te. γ
		21·2 Te. δ			21·9 En. ϵ			9·4 En. ϵ
		22·2 Di. ϵ			22·0 Rh. η			11·2 Te. η
	21	9·7 Rh. η		26	8·0 En. ζ			13·2 Di. θ
		10·8 Di. e			9·5 Di. ϵ			14·2 Mi. θ
		11·4 Mi. ϵ			9·8 Mi. ζ			15·4 Di. δ
		12·9 En. η			11·1 Te. θ			18·6 Di. α
		16·8 Mi. ζ			13·1 Te. δ			19·5 En. ζ
		17·8 Te. ζ			14·4 En. η			20·1 Mi. ϵ
		19·3 En. ϵ			15·8 Mi. η			20·9 Di. ϵ
		19·8 Te. β			16·0 Te. α		4	9·4 Di. e
	22	8·3 Rh. w			18·0 Te. ϵ			9·8 Te. ϵ
		10·0 Mi. ϵ			20·6 Rh. w			10·1 Rh. δ
		11·7 En. η			21·2 Mi. θ			12·0 En. θ
		15·4 Mi. ζ			22·1 Di. e			12·0 Rh. sup.
		16·5 Te. θ		27	9·7 Te. ζ			12·8 Mi. θ
		18·5 Te. δ			10·7 Di. ζ			14·0 Rh. α
		19·6 Di. w			11·7 Te. β			16·5 Rh. ϵ
	23	8·2 Di. θ			12·9 Di. β			18·3 En. ϵ
		8·6 Mi. ϵ			14·4 Mi. η			18·7 Mi. ϵ
		9·4 Rh. δ			14·5 Di. inf.			22·0 Di. ζ
		10·4 Di. δ			14·6 Te. γ		5	8·5 Te. η
		11·4 Rh. sup.			16·2 Di. γ			10·7 En. η
		13·3 Rh. α			16·6 Te. η			11·4 Mi. θ
		13·7 Di. α			16·9 En. ζ			15·1 Rh. e
		14·0 Mi. ζ			18·4 Di. η			17·4 Mi. ϵ
		14·3 En. ζ			19·2 Rh. θ			18·2 Di. w
		15·1 Te. ζ			19·8 Mi. θ			20·8 En. θ
		15·9 Rh. ϵ			21·8 Rh. δ			22·8 Mi. ζ
		15·9 Di. ϵ		28	8·4 Te. θ		6	9·0 Di. δ
		17·1 Te. β			9·3 En. θ			10·1 Mi. θ
		19·9 Mi. η			10·4 Te. δ			12·3 Di. α
		20·0 Te. γ			13·0 Mi. η			13·3 En. ζ
		20·6 En. η			13·3 Te. α			13·7 Rh. ζ
		22·0 Te. η			15·3 Te. ϵ			14·5 Di. ϵ

1893.	G.M.T. h		1893.	G.M.T. h		1893.	G.M.T. h	
Mar. 6	16·0	Mi. ϵ	Mar. 12	9·6	Rh. w	Mar. 16	16·9	Di. w
	16·3	Rh. β		13·0	Mi. ζ		18·8	Mi. θ
	18·2	Rh. inf.		14·4	Di. e		19·9	En. θ
	19·6	En. η		14·8	Te. ζ		22·0	Rh. w
	20·1	Rh. γ		16·8	Te. β	17	8·0	Te. θ
	21·4	Mi. ζ		17·2	En. θ		10·0	Te. δ
	22·7	Rh. γ		19·0	Mi. η		10·9	Di. α
	22·9	Te. ζ		19·7	Te. γ		12·0	Mi. η
7	8·7	Mi. θ		21·7	Te. η		12·3	En. ζ
	12·1	En. ϵ	13	8·2	Rh. θ		12·9	Te. α
	14·6	Mi. ϵ		8·4	Di. γ		13·1	Di. ϵ
	15·6	Di. ζ		9·7	En. ζ		14·9	Te. ϵ
	17·8	Di. β		10·6	Di. η		17·4	Mi. θ
	19·5	Di. inf.		10·8	Rh. δ		18·6	En. η
	20·0	Mi. ζ		11·7	Mi. ζ		20·5	Rh. θ
	21·1	Di. γ		12·7	Rh. sup.	18	8·6	Te. β
	21·3	Rh. w		13·4	Te. θ		10·6	Mi. η
	21·5	Te. θ		14·6	Rh. α		11·1	En. ϵ
	22·2	En. ζ		15·4	Te. δ		11·5	Te. γ
8	11·9	Di. w		16·0	En. η		13·5	Te. η
	13·2	Mi. ϵ		17·2	Rh. ϵ		14·2	Di. ζ
	14·6	En. θ		17·6	Mi. η		16·0	Mi. θ
	18·6	Mi. ζ		18·3	Te. α		16·5	Di. β
	19·9	Rh. θ		20·3	Te. ϵ		19·7	Di. γ
	20·2	Te. ζ	14	8·4	En. ϵ		21·2	En. ζ
	20·9	En. ϵ		10·3	Mi. ζ	19	7·3	Te. δ
	22·2	Te. β		11·8	Di. θ		9·2	Mi. η
	22·4	Rh. δ		12·0	Te. ζ		10·2	Te. α
9	8·2	Di. ϵ		14·0	Di. δ		10·5	Di. w
	11·8	Mi. ϵ		14·0	Te. β		12·2	Tne. ϵ
	13·4	En. η		15·8	Rh. e		13·6	Ei. θ
	17·2	Mi. ζ		16·2	Mi. η		14·6	M. θ
	18·8	Te. θ		16·9	Te. γ		19·9	En. ϵ
	20·7	Di. e		17·3	Di. α		20·5	Mi. ϵ
	20·8	Te. δ		18·5	En. ζ	20	6·8	Di. ϵ
10	9·3	Di. ζ		18·9	Te. η		7·2	Rh. inf.
	10·4	Mi. ϵ		19·5	Di. ϵ		7·9	Mi. η
	11·5	Di. β	15	8·0	Di. e		8·8	Te. γ
	13·1	Di. inf.		8·9	Mi. ζ		9·1	Rh. γ
	14·9	Di. γ		10·7	Te. θ		10·8	Te. η
	15·8	Mi. ζ		11·0	En. θ		11·7	Rh. η
	15·9	En. ζ		12·7	Te. δ		12·4	En. η
	17·0	Di. η		14·4	Rh. ζ		13·3	Mi. θ
	17·5	Te. ζ		14·8	Mi. η		19·2	Mi. ϵ
	19·5	Te. β		15·6	Te. α		19·3	Di. e
	21·7	Mi. η		16·9	Rh. β	21	7·5	Te. α
	22·2	En. η		17·3	En. ϵ		7·9	Di. ζ
	22·4	Te. γ		17·6	Te. ϵ		9·5	Te. ϵ
11	8·5	Rh. γ		18·9	Rh. inf.		10·1	Di. β
	9·0	Mi. ϵ		20·2	Mi. θ		10·3	Rh. w
	11·0	Rh. η		20·6	Di. ζ		11·9	Mi. θ
	14·4	Mi. ζ		20·8	Rh. γ		13·4	Di. γ
	14·7	En. ϵ		22·8	Di. β		14·9	En. ζ
	16·1	Te. θ	16	9·3	Te. ζ		15·6	Di. η
	18·1	Te. δ		9·8	En. η		17·8	Mi. ϵ
	18·1	Di. θ		11·3	Te. β		21·3	En. η
	20·3	Di. δ		13·4	Mi. η	22	8·1	Te. η
	20·3	Mi. η		14·2	Te. γ		8·9	Rh. θ
	21·0	Te. α		16·2	Te. η		10·5	Mi. θ

G.M.T. 1893.	h		G.M.T. 1893.	h		G.M.T. 1893.	h	
Mar. 22	11·4	Rh. δ	Mar. 27	15·5	Di. *w*	Apr. 1	12·3	Te. δ
	13·4	Rh. sup.		17·1	Te. ζ		13·8	Mi. η
	13·7	En. ε		18·9	En. θ		13·9	En. ζ
	15·3	Rh. *a*		19·1	Te. β		14·2	Di. η
	16·4	Mi. ε		20·8	Mi. η		15·2	Te. *a*
	16·7	Di. θ		22·0	Te. γ		17·1	Rh. *e*
	17·9	Rh. ε	28	8·1	Mi. ε		17·2	Te. ε
	18·9	Di. δ		9·5	Di. *a*	2	9·0	Te. ζ
	21·8	Mi. ζ		11·3	En. ζ		11·0	Te. β
	22·2	Di. *a*		11·7	Di. ε		12·4	Mi. η
23	6·8	Te. ε		13·5	Mi. ζ		12·7	En. ε
	9·1	Mi. θ		15·7	Te. θ		13·9	Te. γ
	13·0	Di. *e*		17·6	En. η		15·3	Di. θ
	15·0	Mi. ε		17·7	Te. δ		15·7	Rh. ζ
	16·2	En. θ		19·4	Mi. η		15·9	Te. η
	16·4	Rh. *e*		20·6	Te. *a*		17·5	Di. δ
	20·4	Mi. ζ	29	7·8	Rh. inf.		17·8	Mi. θ
	22·5	Te. ζ		9·8	Rh γ		18·2	Rh. β
	22·6	En. ε		10·1	En. *e*		20·2	Rh. inf.
24	7·0	Di. γ		12·1	Mi. ζ		20·8	Di. *a*
	7·7	Mi. θ		12·3	Rh. η		22·1	Rh. γ
	8·7	En. ζ		12·8	Di. ζ	3	7·6	Te. θ
	9·2	Di. η		14·4	Te. ζ		9·6	Te. δ
	13·6	Mi. ε		15·1	Di. β		11·1	Mi. η
	15·0	En. η		16·4	Te. β		11·6	Di. *e*
	15·0	Rh. ζ		18·0	Mi. η		12·5	Te. *a*
	17·6	Rh. β		18·3	Di. γ		14·5	Te. ε
	19·0	Mi. ζ		19·3	Te. γ		15·2	En. θ
	19·5	Rh. inf.		20·2	En. ζ		16·5	Mi. θ
	21·1	Te. θ		20·5	Di. η		21·6	En. ε
	21·5	Rh. γ		21·3	Te. η	4	7·7	En. ζ
	21·8	Di. *w*	30	9·1	Di. *w*		7·9	Di. η
25	7·4	En. ε		10·7	Mi. ζ		8·2	Te. β
	10·4	Di. θ		10·9	Rh. *w*		9·7	Mi. η
	12·2	Mi. ε		12·6	En. θ		11·1	Te. γ
	12·5	Di. δ		13·0	Te. θ		13·1	Te. η
	15·9	Di. *a*		15·0	Te. δ		14·0	En. η
	17·5	En. ζ		16·6	Mi. η		15·1	Mi. θ
	17·6	Mi. ζ		17·9	Te. *a*		20·4	Di. *w*
	18·1	Di. ε		19·0	En. ε	5	6·8	Rh. ε
	19·8	Te. ζ		19·9	Te. ε		6·9	Te. δ
	21·8	Te. β		21·7	Di. θ		8·3	Mi. η
	22·6	Rh. *w*	31	9·3	Mi. ζ		9·0	Di. θ
26	6·6	Di. *e*		9·5	Rh. θ		9·8	Te. *a*
	10·0	En. θ		11·4	En. η		11·2	Di. δ
	10·8	Mi. ε		11·7	Te. ζ		11·8	Te. ε
	16·2	Mi. ζ		12·1	Rh. δ		13·7	Mi. θ
	16·3	En. ε		13·7	Te. β		14·5	Di. *a*
	18·4	Te. θ		14·0	Rh. sup.		16·6	En. ζ
	19·2	Di. ζ		15·2	Mi. η		16·7	Di. ε
	20·4	Te. δ		15·9	Rh. *a*	6	8·4	Te. γ
	21·2	Rh. θ		16·6	Te. γ		9·0	En. θ
	21·4	Di. β		17·9	Di. *e*		10·4	Te. η
	22·1	Mi. η		18·5	Rh. ε		12·3	Mi. θ
27	6·2	Rh. ε		18·6	Te. η		15·3	En. ε
	8·8	En. η	Apr. 1	8·7	Di. β		17·8	Di. ζ
	9·5	Mi. ε		10·3	Te. θ		18·2	Mi. *e*
	14·9	Mi. ζ		12·0	Di. γ		20·0	Di. β

1893.	G.M.T. h		1893.	G.M.T. h		1893.	G.M.T. h	
Apr. 7	6·6	Rh. β	Apr. 12	20·1	Te. δ	Apr. 18	12·7	Di. w
	7·1	Te. α	13	8·5	Mi. ϵ		12·9	Mi. η
	7·8	En. η		11·7	En. ϵ		13·4	Rh. δ
	8·5	Rh. inf.		13·9	Mi. ζ		14·8	Te. α
	9·1	Te. ϵ		16·9	Di. θ		15·3	Rh. sup.
	10·4	Rh. γ		16·1	Di. δ		16·8	Te. ϵ
	10·9	Mi. θ		16·7	Te. ζ		16·9	En. θ
	13·0	Rh. η		18·7	Te. β		17·3	Rh. α
	14·1	Di. w		19·4	Di. α		18·3	Mi. θ
	16·8	Mi. ϵ		19·8	Mi. η		19·8	Rh. ϵ
	17·9	En. θ		21·6	Te. γ	19	8·6	Te. ζ
8	7·7	Te. η		21·6	Di. ϵ		8·9	Di. ϵ
	8·1	Di. α	14	7·5	Rh. ϵ		9·3	En. ζ
	9·5	Mi. θ		10·2	Di. ϵ		10·6	Te. β
	10·3	En. ζ		12·5	Mi. ζ		11·5	Mi. η
	10·3	Di. ϵ		14·3	En. θ		13·5	Te. γ
	11·6	Rh. w		15·3	Te. θ		15·5	Te. η
	15·4	Mi. ϵ		17·3	Te. δ		15·7	En. η
	16·7	En. η		18·4	Mi. η		16·9	Mi. θ
9	6·4	Te. ϵ		20·2	Te. α		18·4	Rh. ϵ
	8·1	Mi. θ		20·6	En. ϵ	20	9·2	Te. δ
	9·1	En. ϵ	15	6·1	Rh. ϵ		10·1	Di. ζ
	10·2	Rh. θ		6·5	Di. η		10·1	Mi. η
	11·5	Di. ζ		6·7	En. ζ		12·1	Te. α
	12·7	Rh. δ		11·1	Mi. ζ		12·3	Di. β
	13·7	Di. β		13·0	En. η		14·1	Te. ϵ
	14·0	Mi. ϵ		14·0	Te. ζ		15·5	Mi. θ
	14·7	Rh. sup.		16·0	Te. β		15·6	Di. γ
	16·6	Rh. α		17·0	Mi. η		17·0	Rh. ζ
	16·9	Di. γ		18·9	Te. γ		17·8	Di. η
	19·2	Di. η		19·0	Di. w		18·2	En. ζ
	19·2	Rh. ϵ	16	7·2	Rh. β		19·6	Rh. β
	19·2	En. ζ		7·6	Di. θ	21	7·9	Te. β
	19·4	Mi. ζ		9·2	Rh. inf.		8·7	Mi. η
10	7·7	Di. w		9·7	Mi. ζ		10·7	En. θ
	11·6	En. θ		9·8	Di. δ		10·8	Te. γ
	12·7	Mi. ϵ		11·1	Rh. γ		12·8	Te. η
	17·7	Rh. ϵ		12·6	Te. θ		14·1	Mi. θ
	18·0	En. ϵ		13·1	Di. α		17·0	En. ϵ
	18·1	Mi. ζ		13·7	Rh. η		18·9	Di. θ
	20·3	Di. θ		14·6	Te. δ	22	9·4	Te. α
	20·8	Te. θ		15·3	Di. ϵ		9·4	En. η
11	10·4	En. η		15·6	En. ζ		11·4	Te. ϵ
	11·3	Mi. ϵ		15·7	Mi. η		12·7	Mi. θ
	16·3	Rh. ζ		17·5	Te. α		15·2	Di. ϵ
	16·5	Di. ϵ		19·5	Te. ϵ		18·6	Mi. ϵ
	16·7	Mi. ζ	17	8·0	En. θ	23	8·1	Te. γ
	18·9	Rh. β		8·4	Mi. ζ		8·2	Rh. ϵ
	19·4	Te. ζ		11·3	Te. ζ		9·2	Di. γ
	20·5	En. θ		12·2	Rh. w		10·1	Te. η
	20·8	Rh. inf.		13·3	Te. β		11·4	Mi. θ
	21·4	Te. β		14·3	Mi. η		11·4	Di. η
12	7·3	Di. β		14·4	En. ϵ		12·0	En. ζ
	9·9	Mi. ϵ		16·2	Te. γ		17·3	Mi. ϵ
	10·6	Di. γ		16·4	Di. ζ		18·3	En. η
	12·8	Di. η		18·2	Te. η	24	6·8	Rh. ϵ
	12·9	En. ζ		18·6	Di. β		8·7	Te. ϵ
	15·3	Mi. ζ	18	9·9	Te. θ		10·0	Mi. θ
	18·1	Te. θ		10·8	Rh. θ		10·8	En. ϵ
	19·3	En. η		11·9	Te. δ		12·6	Di. θ

1893.	G.M.T. h		1893.	G.M.T. h		1893.	G.M.T. h	
Apr.	24	14·8 Di. δ	May	1	17·5 Mi. η	May	6	18·7 Rh. α
		15·9 Mi. ε			19·9 Te. α			18·7 En. ε
		18·1 Di. α		2	8·9 Rh. ε		7	8·9 Te. δ
	25	7·4 Te. η			9·7 En. θ			9·2 Mi. η
		7·9 Rh. β			10·2 Mi. ζ			11·1 En. η
		8·6 Mi. θ			13·7 Te. ζ			11·8 Te. α
		8·8 Di. e			15·7 Te. β			13·8 Te. ε
		9·8 Rh. inf.			16·0 En. ε			14·6 Mi. θ
		11·8 Rh. γ			16·1 Mi. η			16·3 Di. w
		13·3 En. θ			17·6 Di. θ			19·8 Rh. c
		14·3 Rh. η			18·6 Te. γ		8	7·1 Di. δ
		14·5 Mi. ε			19·8 Di. δ			7·6 Te. β
	26	12·1 En. η		3	7·5 Rh. e			7·8 Mi. η
		12 9 Rh. w			8·5 En. η			10·4 Di. α
		13·1 Mi. ε			8·8 Mi. ζ			10·5 Te. γ
		17·7 Di. w			12·3 Te. θ			12·5 Te. η
		18·5 Mi. ζ			13·8 Di. e			12·6 Di. ε
	27	8·4 Di. δ			14·3 Te. δ			13·2 Mi. θ
		11·5 Rh. θ			14·7 Mi. η			13·7 En. ζ
		11·7 Di. α			17·2 Te. α			18·4 Rh. ζ
		11·7 Mi. ε			18 6 En. θ		9	9·1 Te. α
		13·9 Di. ε			19·2 Te. ε			11 1 Te. ε
		14·1 Rh. δ		4	7·9 Di. γ			11·8 Mi. θ
		14·6 En. ζ			8·6 Rh. β			12·4 En. ε
		16·0 Rh. sup.			10·1 Di. η			13·7 Di. ζ
		17·1 Mi. ζ			10·5 Rh. inf.			15·9 Di. β
		17·9 Rh. α			11·0 Te. ζ			17·7 Mi. ε
	28	10·3 Mi. ε			11·0 En. ζ			19·2 Di. γ
		13·4 En. ε			12·5 Rh. γ		10	7·7 Te. γ
		15·1 Di. ζ			13 0 Te. β			9·7 Te. η
		15·7 Mi. ζ			13·3 Mi. η			10·0 Di. w
		17·3 Di. β			15·0 Rh. η			10·4 Mi. θ
		19·1 Te. ζ			15·9 Te. γ			15·0 En. θ
		19·1 Rh. e			17·4 En. η			16·3 Mi. ε
	29	9·0 Mi. ε			17·9 Te. η		11	6·3 Di. ε
		11·3 Di. w		5	9·6 Te. θ			6·4 Te. α
		14·4 Mi. ζ			9·8 En. ε			7·0 Rh. α
		15·9 En. θ			11·2 Di. θ			7·4 En. ζ
		17·7 Rh. ζ			11·6 Te. δ			8·4 Te. ε
		17·7 Te. θ			12·0 Mi. η			9·1 Mi. θ
		19·7 Te. δ			13·4 Di. δ			9·6 Rh. ε
	30	7·6 Mi. ε			13·6 Rh. w			13·8 En. η
		7·6 Di. ε			14·5 Te. α			15·0 Mi. ε
		8·4 En. ζ			16·5 Te. ε			18·2 Di. e
		13·0 Mi. ζ			16·7 Di. α		12	7·1 Te. η
		14·7 En. η			17·4 Mi. θ			7·4 Di. ζ
		16·4 Te. ζ			18·9 Di. ε			7·7 Mi. θ
		18·4 Te. β		6	7·5 Di. e			8·2 Rh. e
		18·9 Mi. η			8·3 Te. ζ			9·6 Di. β
May	1	7·2 En. ε			10·3 Te. β			12·9 Di. γ
		8 7 Di. ζ			10·6 Mi. η			13·6 Mi. ε
		10·9 Di. β			12·2 Rh. θ			15·1 Di. η
		11·6 Mi. ζ			12·3 En. θ			16·3 En. ζ
		14·2 Di. γ			13·2 Te. γ		13	6 8 Rh. ε
		15·0 Te. θ			14·8 Rh. δ			8·7 En. θ
		16·4 Di. η			15·2 Te. η			9·4 Rh. β
		17·0 Te. δ			16·0 Mi. θ			11·3 Rh. inf.
		17·3 En. ζ			16·7 Rh. sup.			12·2 Mi. ε

1893.	G.M.T. h	
May 13	13·2	Rh. γ
	15·1	En. ϵ
	15·8	Rh. η
	16·2	Di. θ
	17·4	Mi. ζ
	18·4	Di. δ
14	7·5	En. η
	10·8	Mi. ϵ
	12·5	Rh. w
	16·2	Mi. ζ
	17·6	En. θ
	20·1	Te. θ
15	8·8	Di. η
	9·4	Mi. ϵ
	10·1	En. ζ
	13·0	Rh. θ
	14·8	Mi. ζ
	15·5	Rh. δ
	16·4	En. η
	17·5	Rh. sup.
	18·8	Te. ζ
16	8·1	Mi. ϵ
	8·9	En. ϵ
	9·9	Di. θ
	12·1	Di. δ
	13·5	Mi. ζ
	15·4	Di. α
	17·4	Te. θ
	17·6	Di. ϵ
17	11·4	En. θ
	12·1	Mi. ζ
	16·1	Te. ζ
	17·7	En. ϵ
	18·0	Mi. η
	18·1	Ti. β
	18·7	Di. ζ
	19·2	Rh. ζ
18	10·2	En. η
	10·7	Mi. ζ
	14·7	Te. θ
	15·0	Di w
	16·6	Mi. η
	16·7	Te. δ
19	9·1	Di. α
	9·3	Mi. ζ
	11·3	Di. ϵ
	12·7	En. ζ
	13·4	Te. ζ
	15·2	Mi. η
	15·4	Te. β
	18·3	Te. γ
20	7·8	Rh. α
	7·9	Mi. ζ
	10·4	Rh. ϵ
	11·5	En. ϵ
	12·0	Te. θ
	12·4	Di. ζ
	13·8	Mi. η
	14·0	Te. δ

1893.	G.M.T. h	
May 20	14·6	Di. β
	16·9	Te. α
	17·9	Di. γ
21	8·7	Di. w
	9·0	Rh. ϵ
	10·7	Te. ζ
	12·4	Mi. η
	12·7	Te. β
	14·0	En. θ
	17·6	Te. γ
22	7·6	Rh. ζ
	9·3	Te. θ
	10·1	Rh. β
	11·1	Mi. η
	11·3	Te. δ
	12·1	Rh. inf.
	12·8	En. η
	14·0	Rh. γ
	14·2	Te. α
	16·2	Te. ϵ
	16·5	Mi. θ
	16·6	Rh. η
	17·5	Di. ϵ
23	8·0	Te. ζ
	8·3	Di. β
	9·7	Mi. η
	10·0	Te. β
	11·6	Di. γ
	13·8	Di. η
	14·9	Te. γ
	15·1	Mi. θ
	15·2	Rh. w
	15·4	En. ζ
	16·9	Te. η
24	8·6	Te. δ
	11·5	Te. α
	13·5	Te. ϵ
	13·7	Mi. θ
	13·8	Rh. θ
	14·2	En. ϵ
	14·9	Di. θ
	16·3	Rh. δ
	17·1	Di. δ
	18·3	Rh. sup.
25	7·3	Te. β
	10·2	Te. γ
	11·2	Di. ϵ
	12·2	Te. η
	12·3	Mi. θ
	16·7	En. θ
26	7·5	Di. η
	8·8	Te. α
	9·1	En. ζ
	10·8	Te. ϵ
	10·9	Mi. θ
	15·5	En. η
27	7·5	Te. γ
	7·9	En. ϵ
	8·6	Di. θ

1893.	G.M.T. h	
May 27	9·5	Te. η
	9·6	Mi. θ
	10·8	Di. δ
	14·1	Di. α
	15·5	Mi. ϵ
	16·3	Di. ϵ
28	8·1	Te. ϵ
	8·2	Mi. θ
	10·5	En. θ
	14·1	Mi. ϵ
	16·8	En. ϵ
	17·4	Di. ζ
29	8·6	Rh. α
	9·2	En. η
	11·2	Rh. ϵ
	12·7	Mi. ϵ
	13·7	Di. w
30	7·8	Di. α
	9·8	Rh. ϵ
	10·0	Di. ϵ
	11·3	Mi. ϵ
	11·8	En. ζ
	16·7	Mi. ζ
	18·1	En. η
31	8·4	Rh. ζ
	9·9	Mi. ϵ
	10·6	En. ϵ
	10·9	Rh. β
	11·1	Di. ζ
	12·9	Rh. inf.
	13·3	Di. β
	14·8	Rh. γ
	15·3	Mi. ζ
	16·6	Di. γ
	17·4	Rh. η
	18·8	Di. η
June 1	7·4	Di. w
	8·6	Mi. ϵ
	13·1	En. θ
	14·0	Mi. ζ
	16·0	Rh. w
	18·5	Te. ζ
2	11·9	En. η
	12·6	Mi. ζ
	14·6	Rh. θ
	16·2	Di. ϵ
	17·1	Rh. δ
	17·2	Te. θ
3	10·3	Di. γ
	11·2	Mi. ζ
	12·5	Di. η
	14·5	En. ζ
	15·8	Te. ζ
	17·1	Mi. η
	17·8	Te. β
4	9·8	Mi. ζ
	13·2	En. ϵ
	13·7	Di. θ
	14·5	Te. θ

1893.	G.M.T. h		1893.	G.M.T. h		1893.	G.M.T. h	
June 4	15·7	Mi. η	June 10	16·8	Rh. w	June 19	15·0	En. ϵ
	15·9	Di. δ	11	9·7	En. ϵ		17·0	Te. θ
	16·5	Te. δ		9·9	Di. ζ		17·2	Di. β
5	8·4	Mi. ζ		10·0	Te. γ	20	7·5	En. η
	9·9	Di. ϵ		11·5	Mi. θ		10·4	Mi. ζ
	13·1	Te. ζ		12·0	Te. η		11·3	Di. w
	14·3	Mi. η		12·1	Di. β		15·6	Te. ζ
	15·1	Te. β		15·4	Di. γ		16·3	Mi. η
	15·8	En. θ		15·4	Rh. θ		16·3	Rh. θ
6	8·2	En ζ		17·4	Mi. ϵ	21	7·5	Di. ϵ
	11·8	Te. θ		17·6	Di. η		9·0	Mi. ζ
	13·0	Mi. η		18·0	Rh. δ		10·0	En. ζ
	13·8	Te. δ	12	6·2	Di. w		14·3	Te. θ
	14·6	En. η		8·6	Te. α		14·9	Mi. η
	16·7	Te. α		10·1	Mi. θ		16·3	Te. δ
7	7·4	Di. θ		10·6	Te. ϵ		16·4	En. η
	7·5	Rh. sup.		12·2	En. θ	22	8·7	Di. ζ
	9·4	Rh. α		16·0	Mi. ϵ		8·8	En. ϵ
	9·6	Di. δ	13	7·3	Te. γ		10·9	Di. β
	10·4	Te. ζ		8·7	Mi. θ		12·9	Te. ζ
	11·6	Mi. η		9·3	Te. η		13·5	Mi. η
	12·0	Rh. ϵ		11·0	En. η		14·2	Di. γ
	12·4	Te. β		14·6	Mi. ϵ		14·9	Te. β
	12·8	Di. α		15·0	Di. ϵ		16·4	Di. η
	15·1	Di. ϵ	14	7·9	Te. α	23	7·5	Rh. η
	15·3	Te. γ		9·1	Di. γ		11·4	En. θ
	17·0	Mi. θ		9·9	Te. ϵ		11·6	Te. θ
	17·1	En. ζ		11·3	Di. η		12·1	Mi. η
	17·3	Te. η		13·2	Mi. ϵ		13·6	Te. δ
8	9·1	Te. θ		13·6	En. ζ		16·5	Te. α
	9·6	En. θ	15	11·9	Mi. ϵ	24	6·2	Rh. w
	10·2	Mi. η		12·4	En. ϵ		10·1	En. η
	10·6	Rh. ϵ		12·4	Di. θ		10·3	Te. ζ
	11·1	Te. δ		14·6	Di. δ		10·8	Mi. η
	14·0	Te. α	16	8·4	Rh. sup.		12·3	Te. β
	15·6	Mi. θ		8·7	Di. ϵ		13·8	Di. ϵ
	15·9	En. ϵ		10·3	Rh. α		15·2	Te. γ
	16·0	Te. ϵ		10·5	Mi. ϵ	25	7·3	Rh. δ
	16·2	Di. ζ		12·9	Rh. ϵ		7·9	Di. γ
9	7·7	Te. ζ		14·9	En. θ		8·9	Te. θ
	8·4	En. η	17	7·3	En. ζ		9·3	Rh. sup.
	8·8	Mi. η		9·1	Mi. ϵ		10·1	Di. η
	9·2	Rh. ζ		11·5	Rh. ϵ		10·9	Te. δ
	9·7	Te. β		13·7	En. η		11·2	Rh. α
	11·8	Rh. β		14·5	Mi. ζ		13·7	Rh. ϵ
	12·5	Di. w		17·6	Di. w		13·8	Te. α
	12·7	Te. γ	18	8·3	Di. δ		15·8	Te. ϵ
	13·7	Rh. inf.		10·1	Rh. ζ	26	7·6	Te. ζ
	14·2	Mi. θ		11·6	Di. α		9·6	Te. β
	14·7	Te. η		12·1	Mi. ζ		11·2	Di. θ
	15·6	Rh. γ		12·7	Rh. β		12·4	Rh. ϵ
	18·2	Rh. η		13·8	Di. ϵ		12·5	Te. γ
10	8·4	Te. δ		14·6	Rh. inf.		13·5	Di. δ
	8·7	Di. ϵ		16·2	En. ζ		14·5	Te. η
	10·9	En. ζ		16·5	Rh. γ	27	7·5	Di. ϵ
	11·3	Te. α	19	8·7	En. θ		8·2	Te. δ
	12·8	Mi. θ		11·7	Mi. ζ		11·0	Rh. ζ
	13·3	Te. ϵ		15·0	Di. ζ		11·1	Te. α

G.M.T.			G.M.T.			G.M.T.		
1893.	h		1893	h		1893.	h	
June 27	13·1	Te. ϵ	June 29	7·2	Di. δ	June 30	7·1	Te. γ
	13·6	Rh. β		8·5	Te. α		9·1	Te. η
	15·5	Rh. inf.		10·4	Di. α		13·8	Di. ζ
28	9·8	Te. γ		10 5	Te. ϵ		16·0	Di. β
	11·8	Te. η		12·6	Di. ϵ	July 4	10·2	Rh. sup.
	16·4	Di. w						

Colonel Cooper's Observatory,
Markree, Collooney, Ireland.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. FEBRUARY 10, 1893. No. 4

E. B. KNOBEL, Esq., President, in the Chair.

Harold John Adams, M.A., St. John's, Cedars Road, Beckenham, S.E.;
Samuel Barker, 9 Hanover Terrace, Regent's Park, N.W.;
Pat Doyle, F.R.S.E., M.R.I.A., 19 Lall Bazar Street, Calcutta;
Rev. Edwin G. Gange, 135 King Henry's Road, South Hampstead, N.W.;
John Spencer, F.G.S., Rock House, Crawshaw Booth, near Manchester;
Anthony Standidge Thomson, Lieut. R.N.R., F.R.G.S., F.R.M.S., A.I.E.E., Telegraph Works, Silvertown, Essex,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers, from personal knowledge, being appended :—

Ludwig Becker, Ph.D., Professor of Astronomy and Director of the Observatory in the University of Glasgow (proposed by Dr. R. Copeland);
Bernard Edward Cammell, Folly Court, Wokingham, Berks (proposed by George Calver);
Raymond Hill Godfrey, 79 Cornhill, E.C. (Stock Exchange), and Firview, Claygate, near Esher, Surrey (proposed by Professor C. Pritchard);
Samuel Marcus Russell, Professor of Mathematics and Astronomy, Imperial College, Pekin (proposed by Sir R. S. Ball).

Report of the Council to the Seventy-third Annual General Meeting of the Society.

The following table shows the progress and present state of the Society:—

	Compounders	Annual Subscribers	Mathematical Society	Total Fellows	Associates	Patron	Grand Total
December 31, 1891	247	367	3	617	47	1	665
Since elected	+2	+35	...	...	+4	...	...
Deceased	−7	−11	−2	...	−3	...	...
Resigned	...	−11	...	...	...	...	...
Names erased	...	− 5	...	...	...	...	...
Removals	+2	− 2	...	...	...	...	...
December 31, 1892	244	373	1	618	48	1	667

Dr. Common's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balances, 1892 January 1:—						
At Bankers', on current account	243	17	6			
„ on deposit	200	0	0			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	7	19	3			
In hand of Assistant Secretary on Petty Cash Account	0	7	10			
				452	4	7
Dividends on £13,200 Consols, 2¾ per cent. ...	353	18	8			
„ on £650 New 2½-per-cent. Stock. ...	11	19	4			
„ on £1,250 Metropolitan 3 per cent. Stock	36	11	4			
Interest on Money on deposit at Bankers'	0	2	1			
				402	11	5
Received on account of Subscriptions:—						
Arrears	167	8	0			
262 Annual Contributions for 1892	550	4	0			
5 „ „ 1893	10	10	0			
30 Admission Fees	63	0	0			
28 First Contributions	50	8	0			
				841	10	0
4 Composition Fees				84	0	0
Sales of Publications:—						
At Williams & Norgate's, 1891	25	12	2			
At Society's Rooms, 1892	43	18	9			
				69	10	11

Audited and found correct, 1893, January 10.

THOMAS LEWIS,
HAROLD SEWARD.

£1,849 16 11

Astronomical Society, from 1892 January 1 to December 31.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
" " for assistance in editing Society's Publications ...	50	0	0			
				300	0	0
Income Tax and House Duty	10	10	0			
Fire Insurance	7	16	6			
				18	6	6
Printing, &c.	526	4	6			
Engraving and Lithography, &c.	20	7	4			
				546	11	10
Turnor and Horrox Fund: Purchases for Library	7	14	9			
Binding Books in Library	27	10	10			
				35	5	7
Lantern for Evening Meetings—Additional Apparatus, &c.	25	15	6			
Gas-fittings for Lantern	2	0	0			
Oxygen	0	13	6			
Lantern Attendant	4	0	0			
				32	9	0
Decorating	9	15	6			
Sundry Fittings and Repairs	13	16	6			
				23	12	0
Barometer				5	0	0
Copying Press	7	3	6			
Stationery and Office Expenses	15	9	0			
				22	12	6
House Expenses	57	1	6			
Wages	40	12	6			
Postage	68	3	2			
Carriage of Parcels	2	8	11			
Expenses of Meetings	21	18	4			
Coals and Gas	38	10	3			
Electric Light Expenses	1	3	8			
Rental of Wire for Time Signal, &c.	5	18	0			
Care of Fire-extinguishing Apparatus	1	10	11			
Sundries	5	7	5			
				242	14	8
Mrs. Jackson Gwilt's Annuity	8	19	0			
Lee and Janson Fund Grants	15	0	0			
				23	19	0
Purchase of £237 10 10 New 2½-per-cent. Stock at 93⅝, including Commission	222	14	5			
Purchase of £200 New 2½-per-cent. Stock, at 96¼, including Commission	192	15	6			
				415	9	11
Deductions on Cheques				0	4	0
Balances, 1892 December 31:—						
At Bankers', as per Pass Book	163	16	0			
Country Cheques not Credited till 1893 ...	8	8	0			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	10	4	6			
In hand of Assistant Secretary on Petty Cash Account	1	3	5			
				183	11	11
				£1,849	16	11

Assets and Present Property of the Society, 1893 January 1.

	£	s.	d.	£	s.	d.
Balances in hand, December 31, 1892:—						
At Bankers', as per pass book	163	16	0			
Country Cheques not credited till 1893 ...	8	8	0			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	10	4	6			
In hand of Assistant Secretary on Petty Cash Account	1	3	5			
				183	11	11
Due on account of Subscriptions:—						
1 Contribution of 5 years' standing	10	10	0			
10 Contributions of 3 „	63	0	0			
35 „ 2 „	147	0	0			
46 „ 1 „	96	12	0			
7 Admission Fees and 1st Contributions ...	22	1	0			
Other Amounts	7	7	0			
	346	10	0			
Less 5 Contributions paid in advance ...	10	10	0			
				336	0	0
Due from Messrs. Williams & Norgate on account of sales of Publications, 1892				37	11	6
Due from Messrs. Wesley & Son, from sale of old non-astronomical books				5	19	9
£13,200 2¾-per-cent. Consols, including the Lee and Janson Fund, the Turnor Fund, the Horrox Memorial Fund, and Mrs. Jackson Gwilt's gift.						
£650 New 2½-per-cent. Consols.						
£1,250 Metropolitan 3-per-cent. Stock.						
Astronomical and other Manuscripts, Books, Prints, and Instruments; Furniture, &c.						
Unsold Publications of the Society.						
4 Gold Medals.						

Trust Funds.

The Turnor Fund: A sum of £450 2¾-per-cent. Consols, the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £100 2¾-per-cent. Consols, the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £323 16*s.* 3*d.* 2¾-per-cent. Consols, the interest to be given by the Council to the widow or orphan of any deceased Fellow or Associate of the Society who may stand in need of it.

Mrs. Jackson Gwilt's Gift: A sum of £300 2¾-per-cent. Consols, subject to an annuity to the donor, during her life, of £8 19*s.* per annum.

Report of the Auditors.

We have examined the Treasurer's accounts for the year 1892, and have found and certified the same to be correct. The cash in hand on December 31, 1892, including the balance at the bankers', &c., amounted to £183 11*s.* 11*d.*

The funded property of the Society has been increased by the purchase of £437 10*s.* 10*d.* New 2½-per-cent. stock.

The books, instruments, and other effects have been examined, and they appear to be in a satisfactory condition. Some instruments belonging to the Society appear to have been lent for a considerable number of years: we think it desirable that a renewed acknowledgment should in such cases be given for these.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting, with the amount due against each Fellow's name.

(Signed) THOMAS LEWIS,
HAROLD SEWARD.

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At William & Norgate's
I. Part 1	7	...	XXX.	156	...
I. Part 2	42	...	XXXI.	139	...
II. Part 1	54	...	XXXII.	151	...
II. Part 2	20	...	XXXIII.	160	1
III. Part 1	65	1	XXXIV.	162	3
III. Part 2	84	1	XXXV.	107	5
IV. Part 1	77	3	XXXVI.	195	8
IV. Part 2	90	3	XXXVII. Part 1	336	8
V.	102	3	XXXVII. Part 2	282	8
VI.	123	3	XXXVIII.	267	1
VII.	142	3	XXXIX. Part 1	236	1
VIII.	126	3	XXXIX. Part 2	241	3
IX.	133	3	XL.	258	1
X.	143	...	XLI.	406	1
XI.	152	...	XLII.	232	3
XII.	159	...	XLIII.	235	1
XIII.	159	...	XLIV.	214	1
XIV.	365	...	XLV.	246	...
XV.	137	...	XLVI.	227	1
XVI.	163	1	XLVII. Part 1	3	...
XVII.	146	1	XLVII. Part 2	18	...
XVIII.	143	1	XLVII. Part 3	2	...
XIX.	147	1	XLVII. Part 4	10	...
XX.	139	1	XLVII. Part 5	8	...
XXI. Part 1	312	...	XLVII. Part 6	9	...
XXI. Part 2	98	...	XLVII.	202	2
XXI. 1 & 2 (together)	59	1	XLVIII. Part 1	246	2
XXII.	161	1	XLVIII. Part 2	255	2
XXIII.	145	1	XLIX. Part 1	450	1
XXIV.	153	1	XLIX. Part 2	317	1
XXV.	163	...	L.	385	4
XXVI.	174	1	Index to *Memoirs*	638	1
XXVII.	421	1			
XXVIII.	380	1			
XXIX.	402	...			

Stock in hand of volumes of the *Monthly Notices* :—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	63	...	XXVIII.	71	...
II.	65	...	XXIX.	51	...
III.	...	...	XXX.	64	2
IV.	...	...	XXXI.	92	...
V.	...	...	XXXII.	115	5
VI.	50	...	XXXIII.	97	...
VII.	2	...	XXXIV.	75	1
VIII.	153	2	XXXV.	54	...
IX.	24	3	XXXVI.	30	1
X.	178	1	XXXVII.	37	3
XI.	184	...	XXXVIII.	100	2
XII.	106	2	XXXIX.	97	1
XIII.	178	2	XL.	110	3
XIV.	177	3	XLI.	110	5
XV.	169	2	XLII.	120	1
XVI.	154	1	XLIII.	116	2
XVII.	167	1	XLIV.	119	2
XVIII.	244	...	XLV.	121	...
XIX.	56	...	XLVI.	116	...
XX.	30	...	XLVII.	134	4
XXI.	17	...	XLVIII.	126	2
XXII.	33	...	XLIX.	120	10
XXIII.	19	...	L.	123	13
XXIV.	24	...	LI.	134	11
XXV.	15	...	LII.	124	15
XXVI.	11	...	Index ...	564	3
XXVII.	4	...			

LIBRARY CATALOGUE 570

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to LII., no complete volumes can be formed from the separate numbers in stock.

Instruments belonging to the Society.

No. 1. The *Harrison* clock.
,, 2. The *Owen* portable circles, by Jones.
,, 3. The *Beaufoy* circle.

No. 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatoreal.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatoreal.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatoreal, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.
The *Sheepshanks* collection :—
„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumb-line; portable clamping foot and tripod stand.
„ 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
„ 33. (7) 2-foot navy telescope.
„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Ys for fixing to stone piers; two axis levels.
„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

No. 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

No. 51. (25) Ordinary 4½-inch compass with needle.
„ 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton; a 10½-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane 2⅜-inch speculum, artificial horizon, and stand.
„ 59. (33) 2½-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough; the trough 8¼ by 4½ inches; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. 9¼-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.
„ 86. 4½-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.

No. 87. 3¼-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, 5¾ inches in diameter.
„ 91. Astronomical time watchcase, by Professor Chevallier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass 2½ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.
„ 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 116. A pair of 18-inch globes.
„ 117, „ 118. Two old sun-dials.

No. 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.
„ 120. A 6-prism spectroscope, by Browning.
„ 121. Spitta's improved maximum and minimum thermometer.
„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-in. portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere, presented by Prof. Slater.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons:—

No.	4.		The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
„	10.		Variation transit, to Mr. Maxwell Hall.
„	16.		The *Wollaston* telescope, to Mr. R. Inwards.
„	22.		The *Matthew* equatoreal, to Mr. J. Brett.
„	23.		The *Matthew* transit, to Captain W. Noble.
„	28.	(2)	6-inch theodolite and stand, to Dr. A. A. Common.
„	29.	(3)	Wire micrometer (No. 1), to Mr. C. Thwaites.
„	„	„	Wire micrometer (No. 2), to Mr. Maxwell Hall.
„	30.	(4)	$3\frac{1}{4}$-inch equatoreal and stand, to Mr. E. B. Powell.
„	„	„	Double-image micrometer, to Mr. Maxwell Hall.
„	31.	(5)	$2\frac{3}{4}$-inch telescope and stand, to Mr. F. J. Wardale.
„	34.	(8)	Transit instrument and stand, to Professor C. Pritchard.
„	38.	(12)	18-inch *Borda* repeating circle, to Mr. Maxwell Hall.
„	39.	(13)	8-inch repeating circle, to Mr. J. Norman Lockyer.
„	42.	(16)	Artificial horizon, roof, and mercury bottle, to Mr. C. Thwaites.
„	50.	(24)	Prismatic compass, to Mr. Maxwell Hall.
„	52.	(26)	Dipping needle, to Mr. Maxwell Hall.
„	54.	(28)	Magnetic intensity needle, to Mr. Maxwell Hall.
„	69.	(43)	Telescope, with rock-crystal object-glass, to Dr. W. Huggins.
„	74.		Registering spectroscope, to Mr. John Mitchell.
„	78.		$9\frac{1}{4}$-inch reflector and stand, to Mr. Maxwell Hall.

No. 79.	Spectroscope, to Mr. Maxwell Hall.
„ 92.	2½-inch navy telescope, to Mr. M. D. Severn.
„ 99.	12-inch portable transit instrument, to Mr. H. T. Vivian.
„ 120.	6-prism spectroscope, by Browning, to Mr. C. Thwaites.
„ 123.	6-inch refractor, by Grubb, with three eyepieces, to Mr. W. E. Wilson.
„ 124.	Position micrometer, by Cooke, to the Rev. A. Freeman.
„ 125.	One dark wedge, to the Rev. A. Freeman.
„ 126.	3½-inch portable refractor, by Tulley, to Mr. H. Sadler.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Professor H. C. Vogel for his Spectroscopic and other Astronomical Observations.

Publications of the Society.

Volume L. of the *Memoirs* has been published during the past year; it contains the following papers:—

"Fifth Catalogue of Micrometrical Measures of Double Stars made at the Temple Observatory, Rugby." By G. M. Seabroke, A. P. Smith, and H. P. Highton.

"Observations of the Spectra of Sun-spots in the Region B—D made at the Stonyhurst College Observatory." By the Rev. A. L. Cortie.

"Measures of Double Stars made at Sydney Observatory in the years 1882–89." Communicated by H. C. Russell.

"Double-star Observations, 1888–91." By W. H. Maw.

"On the Construction of a Five-foot Equatorial Reflecting Telescope." By A. A. Common.

The attention of foreign and American astronomers is requested to the following paragraph in the Report of the Council for 1879. It is against the rules of the Society to print any paper previously published:—

"The Council hope that the communication between English and foreign astronomers will continue to increase, but they take this opportunity of mentioning that some of the papers which have been received by the Society have not been printed on account of their having been previously published abroad."

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—Rev. Edward Allen.
Robert Grant.
John Hartnup.
Thomas Archer Hirst.
Joseph Kleiber.
Benjamin Loewy.
W. Edwards Michell.
Rev. I. Vale Mummery.
A. V. Nursing Row.
Captain G. C. Parker.
Charles Greville Prideaux.
Rev. Joseph Spear.
Thomas Taylor.
George Turnbull.
W. Mattieu Williams.

Associates:—Annibale de Gasparis.
Admiral E. Mouchez.
Lewis M. Rutherfurd.

John Couch Adams was born on June 5, 1819, at the farm-house of Lidcot, seven miles from Launceston, in Cornwall. His father was a tenant farmer, and his mother possessed a small estate of land of her own. She had also inherited her uncle's library, and these books, which included some on astronomy, were his early companions. At the village school at Laneast he made rapid progress, and was learning algebra before he was twelve years old. At this age he went to a private school at Devonport, kept by the Rev. John Couch Grylls, a first cousin of his mother.

He remained under Mr. Grylls's tuition for a good many years, first at Devonport and afterwards at Saltash and Landulph, and received the usual school training in classics and mathematics. Astronomy had been his passion from very early boyhood, and at fourteen years of age he made copious notes and drew tiny maps of the constellations. He read with avidity all the astronomical books to which he could obtain access, and in particular he studied the astronomical articles in Rees's

"Cyclopædia," which he met with in the library of the Devonport Mechanics' Institute, where he used to spend his spare time in reading astronomy and mathematics. In the same library he came across a copy of Vince's "Fluxions," which was his first introduction to the higher mathematics.

He showed such signs of mathematical power that in 1837 the idea of his going to Cambridge was entertained. He accordingly entered St. John's College, Cambridge, in October 1839. During his undergraduate career he was invariably the first man of his year in the college examinations, and in 1843 he graduated as Senior Wrangler, being also first Smith's Prizeman. In the same year he was elected Fellow of his college.

His attention was drawn to the irregularities in the motion of *Uranus* by reading Airy's report upon recent progress in astronomy in the British Association volume for 1831–32,* and on July 3, 1841, he made the following memorandum:— "Formed a design at the beginning of this week of investigating, as soon as possible after taking my degree, the irregularities in the motion of *Uranus* which are yet unaccounted for, in order to find whether they may be attributed to the action of an undiscovered planet beyond it; and, if possible, thence to determine the elements of its orbit &c. approximately, which would probably lead to its discovery." This memorandum was made at the beginning of his second long vacation, when he was in his twenty-third year.†

In 1843, the year in which he took his degree, he attempted a first rough solution of the problem on the assumption that the orbit was a circle with a radius equal to twice the mean distance of *Uranus* from the Sun. The result showed that a good general agreement between theory and observation might be obtained. In order to make the data employed more complete application was made through Professor Challis to the Astronomer Royal for the results of the Greenwich observations of *Uranus*. When these were obtained Adams undertook a new solution of the problem, taking into account the most important terms depending on the first power of the eccentricity of the orbit of the supposed disturbing planet, but retaining the same assumption as before with respect to the mean distance. In September, 1845, he communicated to Professor Challis the values which he had obtained for the mass, heliocentric longitude, and elements of the orbit of the assumed planet. The same results, slightly corrected, he took with him to the Royal Observatory, Greenwich, on October 21, 1845. The paper which he left at the Observatory on this occasion also contained a list

* This report does not contain any reference to the irregularities being possibly due to an exterior planet. It is merely mentioned that it seems impossible to unite all the observations in one elliptic orbit, and that Bouvard was therefore obliged to reject the ancient observations entirely (p. 154).

† The original memorandum, written by itself on a slip of paper, has been found among his papers since his death.

of the residual errors of the mean longitude of *Uranus*, after taking account of the disturbing effect of the new planet, at dates extending from 1690 to 1840.

On November 10, 1845, Le Verrier presented to the French Academy an elaborate investigation of the perturbations of *Uranus* produced by *Jupiter* and *Saturn*, in which he pointed out several small inequalities which had previously been neglected. After taking these into account, and correcting the elements of the orbit, he still found that the theory was quite incapable of explaining the observed irregularities in the motion of *Uranus*.

On June 1, 1846, Le Verrier presented to the French Academy his second memoir on the theory of *Uranus*, in which he concluded that the unexplained irregularities in the motion of *Uranus* were due to the action of an undiscovered planet exterior to *Uranus*. He investigated the elements of the orbit of such a planet, and, assuming its mean distance to be double that of *Uranus*, and its orbit to be in the plane of the ecliptic, he found that the most probable value of the true longitude of the disturbing body for the beginning of 1847 was about 325°, but he did not give the elements of the orbit or the mass of the planet.

The place thus assigned by Le Verrier to the disturbing planet differed by only 1° from that given by Adams in the paper which he had left at the Greenwich Observatory seven months earlier. Le Verrier's third memoir, in which he gave the elements of the orbit, was communicated to the French Academy on August 31, 1846.

Professor Challis commenced the search for the planet with the Northumberland telescope of the Cambridge Observatory on July 29, 1846, three weeks before the planet was in opposition, and the observations were continued for two months. His plan was to examine a zodiacal zone having its centre in the ecliptic at 325° of longitude, and extending 15° of longitude in each direction from the central point, and from 5° north latitude to 5° south latitude. He proposed to make two sweeps over each portion of the zone, so that, when the observations were compared, a planet could be at once detected by its motion in the interval. For the first few nights the telescope was directed to the part of the zone in the immediate neighbourhood of the place indicated by theory. Unfortunately the observations were not immediately compared with each other, or Professor Challis would have discovered, what he found afterwards to be the case, that he had actually observed the planet on August 4 and August 12, the third and fourth nights of observation. The star-map of the Berlin Academy for Hora xxi. of right ascension had lately been published, but the English astronomers were not aware of its existence. By the help of this map the search would have been extremely easy and rapid, as the observations could have been compared with the map as fast as they were made.

On September 3, 1846, Adams communicated to the Astro-

nomer Royal a new solution of the problem, supposing the mean distance of the planet as originally assumed to be diminished by about the $\frac{1}{30}$th part. The result of this change was to produce a better agreement between the theory and the later observations, and to give a smaller and therefore a more probable value of the eccentricity. Meanwhile, on August 3, 1846, Le Verrier had presented to the French Academy his second paper upon the place of the disturbing planet, which, however, did not reach this country till the third or fourth week in September. In this elaborate paper Le Verrier obtained elements of the orbit of the disturbing planet, which are very similar to those obtained in Adams's second solution. Le Verrier communicated his principal conclusions to Dr. Galle, of the Berlin Observatory, in a letter received by him on September 23, 1846, and, by comparing his observations with the Berlin star-map, Dr. Galle found the planet on the same evening.

Adams's researches, therefore, preceded Le Verrier's by a considerable interval; and, in spite of the delay in commencing the search, it had been carried on at Cambridge for nearly two months before the planet was found at Berlin. Adams's investigation may be regarded as having been completed on October 21, 1845, when he left his paper at the Royal Observatory. This was three weeks before Le Verrier's memoir, showing that the irregularities could not be attributed to the known planets, was presented to the French Academy, and more than seven months before the date of presentation of his second memoir. As we know, Adams had resolved to undertake the work in 1841, and his first solution was effected, as soon as he had leisure, in 1843. We may presume that Le Verrier did not attempt the actual solution until after the completion of his memoir of November 10, 1845.

The discovery of the actual planet by Dr. Galle, in consequence of Le Verrier's prediction, was received with the most unbounded enthusiasm by astronomers of all countries, and the planet was at once called *Le Verrier's Planet.* Adams's work was only known to Airy, Challis, and a few other persons, chiefly private friends. The first public mention of his name occurred in a letter written by Sir J. Herschel on October 1, which appeared under the heading "Le Verrier's Planet" in the *Athenæum* for October 3, 1846. He refers to the address he had delivered on September 10, on the occasion of resigning the Presidential Chair of the British Association at Southampton, in which, after referring to the astronomical events of the year, among which was included the discovery of a new planet, he added the words—"It has done more. It has given us the probable prospect of the discovery of another. We see it as Columbus saw America from the shores of Spain. Its movements have been felt, trembling along the far-reaching line of our analysis, with a certainty hardly inferior to that of ocular demonstration."

To justify the confidence which these words express, Herschel first describes a conversation with Bessel in 1842, in which the latter had said that it was highly probable that the deviations of *Uranus* might be due to an unknown planet (being systematic, and such as an exterior planet would produce), and then proceeds :—

"The remarkable calculations of M. Le Verrier, which have pointed out, as now appears, nearly the true situation of the new planet by resolving the inverse problem of the perturbations—if uncorroborated by repetition of the numerical calculations by another hand, or by independent investigation from another quarter—would hardly justify so strong an assurance as that conveyed by my expressions above alluded to. But it was known to me at that time (I will take the liberty to cite the Astronomer Royal as my authority) that a similar investigation had been independently entered into, and a conclusion as to the situation of the new planet very nearly coincident with M. Le Verrier's arrived at (in entire ignorance of his conclusions) by a young Cambridge mathematician, Mr. Adams, who will, I hope, pardon this mention of his name (the matter being one of great historical moment), and who will, doubtless in his own good time and manner, place his calculations before the public."

This passage seems to have passed almost unnoticed, however, in the outburst of enthusiasm with which Le Verrier's discovery was hailed, and it was not till October 17, when a letter from Challis appeared in the *Athenæum*, giving an account of the circumstances, that attention was directed to Adams's calculations. It was then for the first time known that his conclusions had been in the hands of the Astronomer Royal and Challis since 1845, and that the latter had actually been engaged in searching for the planet. There was naturally a disinclination to give full credit to facts thus suddenly brought to light at such a time. It was startling to realise that the Astronomer Royal had had in his possession the data which would have enabled the planet to have been discovered nearly a year before. On the other hand, it seemed extraordinary that a competent mathematician, who had determined the orbit of the disturbing planet, should have been content to refrain for so long from making public his results. No time was now lost in bringing the evidence before the world. On November 13, 1846, Airy communicated to the Society an "Account of some Circumstances historically connected with the Discovery of the Planet exterior to *Uranus*"; and Challis also described the observations which he had undertaken in search of the planet. At the same meeting Adams communicated a memoir containing an account of his mathematical investigations in connection with the determination of the mass, orbit, and position of the new planet, by which he had obtained the elements communicated to the Astronomer Royal on October 21, 1845, and September 3, 1846. All of these papers are published in vol. xvi. of the *Memoirs*; but as it was felt that the immediate publication and circulation of Adams's memoir was a

matter of national interest, it was at once printed separately by Lieut. Stratford, superintendent of the *Nautical Almanac* Office, as a special appendix to the *Nautical Almanac* for 1851, and widely circulated at the beginning of 1847. This appendix was also circulated as a supplement to No. 593 (1847 March 2) of the *Astronomische Nachrichten*. It is not necessary here to discuss the question whether blame can fairly be laid to the charge of Airy or any of the other persons concerned. There is, fortunately, no dispute whatever about the facts, and in a letter to Sheepshanks, which is in the possession of the Society, Adams expressed himself as quite satisfied with Airy's statement of the case. It is perfectly true that Adams, as was said at the time, conducted himself more like a "bashful boy" than an investigator who had made a magnificent discovery. It is also true that he did not reply to an inquiry of Airy's, thinking it trivial. On the other hand, we are met by Airy's apparent indifference to Adams's results in comparison with the enthusiasm with which he greeted Le Verrier's results and prediction, although the honour of the actual discovery might have belonged to this country if he had shown more interest in the researches that had been carried out in his own university.

The French astronomers, especially Arago, were at first very unwilling to admit that Adams had any right whatever in connection with the planet, either as an independent discoverer or otherwise. Strange as it may seem, this view was also taken by some English astronomers, who, giving full credit to Le Verrier, denied all merit to Adams. It was contended that the fact that Adams's results had not been announced publicly, but had been merely communicated to the Astronomer Royal and a few others, deprived him of all claims in relation to the discovery. As has been stated, Adams himself, immediately after the finding of the planet, wrote out his investigations and submitted them to the Society; but neither then nor at any subsequent time did he take any part in the discussion himself, nor did he ever write or speak an unfriendly word with respect to anyone concerned in it. In France a very fair view of the matter was taken by Biot, and in England the speedy recognition of the merits of Adams's researches was mainly due to the warm and generous advocacy of two Cambridge men—Sedgwick and Sheepshanks, the latter of whom was at that time Secretary of the Society and Editor of the *Monthly Notices*.*

* In an interesting letter to Schumacher, now in the possession of the Society, Sheepshanks wrote as follows, under date April 7, 1847:—"You will be surprised when I tell you that the *strongest* opponents to Mr. Adams's claims to consideration are to be found in England, of course with the exception of France. All acknowledge M. LeVerrier's merits, and all admit his *undoubted* claim to *independent* discovery. All are agreed, too, that in *making public his results and investigations* in the masterly and confident way he did, he deserves the highest praise. As to *national* feeling (which, by the way, is too often national injustice) there is absolutely none whatever, so far as I know, or

The Royal Society at once awarded their highest honour, the Copley Medal, to Le Verrier (1846), and it was not till two years afterwards that it was awarded to Adams.* Our Society was saved from expressing a similar preference by the bye-law requiring that the award of the medal should be confirmed by a majority of three-quarters of the Council. A sufficient minority were of opinion that "an award to M. Le Verrier, unaccompanied by another to Mr. Adams, would be drawing a greater distinction between the two than fairly represents the proper inference from facts, and would be an injustice to the latter." * It had been proposed that the General Meeting should be recommended to suspend the existing bye-law, so that more than one medal might be given, but the proposal was not carried on the Council. No medal of the Society has been awarded in connection with the discovery of *Neptune*, either at that time or subsequently.

Looking back now upon Adams's achievement, which, as has been truly said, belongs at once to the science and the romance of astronomy, there are several points that stand out as very remarkable: his extreme youth when he attacked, unaided, so difficult a problem, and steadily carried it through to success; his faith in the Newtonian law and in the results of his own mathematics; and his extreme modesty. As soon as he took his degree in 1843 he devoted his whole leisure, in term time at Cambridge, and in vacations in Cornwall, to the new planet's orbit, without assistance or encouragement from anyone. How quietly and unassumingly he pursued his investigations is shown by the fact that at the time of the finding of the planet his name was only known to Airy, Challis, Herschel,

among astronomers. In England at present the current runs the other way, and though I very much prefer this failing of the two, yet it is provoking too. I assure you that it was with difficulty that one could get a hearing, while pointing out the fact that Mr. Adams had deduced the elements and place of the planet in October 1845. I have been told repeatedly by those who should have known better that this was nothing at all, simply because the over-modest man communicated his results to Airy and Challis, that the planet might be looked for, instead of bringing his investigation before the world as he ought to have done. Surely it is a greater honour to science that two men should independently have come to the same conclusion from the same data than that one should have hit on it, as it were, accidentally. Thanks to Struve and Biot, &c. our anti-Adamites are calmer, and as there never was any opposition to Le Verrier, we are quite satisfied at present, and so I hope are the two discoverers. I think there is a hope that Mr. Adams will continue his astronomical researches. In any other country there could be no doubt of it, but in England there is no *carrière* for men of science. The Law or the Church seizes on all talent which is not independently rich or careless about wealth." The principal contemporary publications relating to the new planet are to be found in vol. xvi. of the *Memoirs*, in the *Comptes Rendus*, in the *Athenæum*, in the *Astronomische Nachrichten*, and in vol. vii. (1847) of the *North British Review*, which contains an article by Brewster. Challis's report of December 12, 1846, to the Observatory Syndicate at Cambridge, which contains an account of his own proceedings relating to the new planet, was published in the *Monthly Notices* for 1883 (vol. xliii. pp. 165–172).

* *Monthly Notices*, vol. vii. p. 216.

Earnshaw, and a few intimate university friends of his own standing. The implicit reliance that he placed in the sufficiency of the Newtonian law to explain all the phenomena of the heavens is also noteworthy, as it was then considered much more likely than it is now that the true law might not be exactly that of the inverse square, or might be subject to other modifications.* He was perfectly convinced of the reality of the planet and of the approximate accuracy of the place he had assigned to it; and in the paper which he placed in the hands of Challis in September, 1845, he used the words "the new planet." It is to be regretted that he should have refrained from publishing his results at the time (which he had been advised to do by some of his Cambridge friends), but he can scarcely be blamed for believing that the course he had taken would lead to a search being made for the planet at Greenwich or elsewhere.

A French translation of the memoir presented to the Society in 1846 was published in Liouville's *Journal de Mathématiques Pures et Appliquées* for 1875. The Editor, M. Résal, stated

* The words in the text were in type before the writer saw a private letter from Adams to Professor James Thomson, dated November 26, 1846, from which the following very interesting sentences relating to this subject are extracted:—"On considering the subject it appeared to me that by far the most probable hypothesis that could be formed to account for these irregularities was that of the existence of an exterior undiscovered planet whose action on *Uranus* produced the disturbances in question. None of the other hypotheses that had been thrown out seemed to possess the slightest claims to attention, as they were all improbable in themselves, and incapable of being tested by any exact calculation. Some had even supposed that, at the great distance of *Uranus* from the Sun, the law of attraction became different from that of the inverse square of the distance, but the law of gravitation was too firmly established for this to be admitted till every other hypothesis had failed to account for the observed irregularities; and I felt convinced that in this, as in all previous instances of the kind, the discrepancies which had for a time thrown doubts on the truth of the law, would eventually afford it the most striking confirmation. In contrast with all these vague hypotheses, the supposition that the irregularities were caused by the action of an unknown planet appeared to be thoroughly in accordance with the present state of our knowledge, could be tested by calculation, and would probably lead to important practical results—viz. the approximate determination of the position of the disturbing body." After quoting the memorandum of July 3, 1841, he proceeds:—"Accordingly, in 1843, I commenced my calculations, and in the course of that year I arrived at a first solution of the problem, which, though incomplete in itself, fully convinced me that the hypothesis which I had formed was quite adequate to account for the observed irregularities, and that the place of the disturbing body might be very approximately determined by a more extended investigation. Having received from the Astronomer Royal, in February 1844, the whole of the Greenwich observations of *Uranus*, I accordingly attacked the problem afresh, and in a much more complete manner than before, and, after obtaining several solutions, differing little from each other, by gradually taking into account more and more terms in the series expressing the perturbations, I communicated my final results to Professor Challis in September 1845, and the same, slightly corrected, to the Astronomer Royal in the following month. The near agreement of the several solutions which I had obtained gave me great confidence in my results, which included a determination of the mass, position, and elements of the orbit of the supposed planet."

that he had been led to undertake this republication by the pressing solicitations of several eminent mathematicians. In introducing the memoir he writes:—"Le problème fut résolu simultanément, en Angleterre par M. Adams, et en France par M. Leverrier, qui, ainsi que le reconnaît M. Adams, a publié le premier les résultats de ses recherches. . . . Il est impossible de rencontrer, dans l'histoire des sciences, une découverte qui fasse plus d'honneur au génie humain. Les lois de Newton recevaient ainsi la plus éclatante des confirmations, et l'Astronomie, désormais indiscutable dans ses principes, était arrivée à l'état de science parfaite. Le Mémoire de M. Adams a valu, à juste titre, à son auteur la plus glorieuse célébrité: il est digne, en effet, de figurer à côté des plus beaux mémoires de Laplace et Lagrange." This republication of the memoir, after an interval of thirty years, in a purely mathematical journal, derives additional interest from the fact that the author himself has added a few notes at the end, some of which relate to the objections made by Professor Benjamin Peirce to the legitimacy of the methods pursued by both Adams and Le Verrier. In Peirce's paper, which was published in 1847, he contended that the period of *Neptune* differed so considerably from that of the hypothetical planets that the modes of procedure adopted were unreliable, so that the finding of the planet was partly due to a happy accident. In reply to this, Adams points out that the objection would be valid if the object in view had been to represent the perturbations of *Uranus* during two or three synodic periods, but that the case is different when, as in this instance, it is only required to represent the perturbations for a fraction of a synodic period.

The honours so freely and deservedly bestowed upon Le Verrier in France and other countries form a striking contrast to the general want of appreciation with which Adams's work was at first received. But there were conspicuous exceptions. In 1847, on the occasion of the Queen's visit to Cambridge, the honour of knighthood was offered to Adams, but this offer he felt obliged to decline. The members of St. John's College, also, were not slow in showing their sense of the honour he had conferred on his college and the University, for in a very short time a fund, producing about 80*l.* per annum, was raised for establishing a prize to be connected with his name. This fund was offered to the University, and accepted on April 7, 1848. The Adams Prize, which is biennial, is awarded for the best essay on some subject of pure mathematics, astronomy, or other branch of natural philosophy. It was awarded in 1857 to Clerk Maxwell for his well-known essay on the stability of *Saturn's* rings.

Before leaving the subject of *Neptune*, it should be stated that Adams always expressed the warmest appreciation of Le Verrier's work. It was a great pleasure to him when they met at Oxford in 1847. In the same year Le Verrier visited Adams at

Cambridge. The honorary degree of LL.D. was conferred upon Le Verrier in 1874 by the University of Cambridge, and it cannot be doubted that this was owing to the action of Adams.

In 1847 he communicated to the Society a paper on an important error in Bouvard's tables of *Saturn*. Having been engaged upon a comparison of the theory of *Saturn* with the Greenwich observations, he was struck with the magnitude of the tabular errors in heliocentric latitude, which could not be attributed to imperfections in the theory. He found that the error was one of computation, two terms of different arguments having been, in effect, united into one.

In 1848 he was occupied with the determination of the constants in Gauss's theory of terrestrial magnetism. This investigation he afterwards resumed, and the calculations connected with it, with which he was occupied in the later years of his life, were left unfinished at the time of death. When failing health prevented him from any longer giving his personal attention to the work, he placed the manuscripts in the hands of his brother, Professor W. G. Adams, for completion.

In 1851 he was elected President of our Society, and held the office for the usual term of two years, during which he delivered the addresses on the presentation of the medal to Peters and to Hind. In 1852 he communicated to the Society new tables of the Moon's parallax, to be substituted for those of Burckhardt. Henderson had compared the parallaxes deduced from observation with those derived by calculation from the tables both of Damoiseau and of Burckhardt, finding a difference of no less than $1''\cdot3$, according as one set of tables or the other was employed. The parallax in Damoiseau's tables is given at once in the form in which it is furnished by theory, but that in Burckhardt's tables is adapted to his peculiar form of the arguments, and requires transformation in order to be compared with the former. When this was done, Adams found that several of the minor equations of parallax deduced from Burckhardt differed completely from their theoretical values as given by Damoiseau. He discovered that these errors were due to Burckhardt's transformations of Laplace's formula, and he succeeded in tracing them to their sources. He also examined carefully the theories of Damoiseau, Plana, and Pontécoulant, with respect to the same subject, and supplied a number of defects and omissions. Burckhardt's value of the parallax having been employed in the *Nautical Almanac*, Adams gave, in addition to the new tables, a table of corrections to be applied to the values in the *Nautical Almanac* for every day of the year from 1840 to 1855 inclusive. This contribution to astronomy is very characteristic of its author. It contains the results of an immense amount of intricate and elaborate mathematical investigation, carried out with great skill and accuracy in all its details, both analytical and numerical, but no part of the work itself is given. The method of procedure is briefly sketched, and the final conclusions are stated in the fewest words and simplest manner possible. No

one unacquainted with the subject would imagine how much difficult and laborious research was represented by these few pages of results. The tables were printed as a supplement to the *Nautical Almanac* for 1856.

As Adams had not taken holy orders, his Fellowship at St. John's College came to an end in 1852, but he continued to reside in the college until February 1853, when he was elected to a Fellowship at Pembroke College, which he retained till his death. In the autumn of 1858 he was appointed Professor of Mathematics in the University of St. Andrews, and shortly afterwards, in the same year, he was elected Lowndean Professor of Astronomy and Geometry at Cambridge, in succession to Peacock. He continued his lectures at St. Andrews, however, until the end of the session in May 1859. In 1861 he succeeded Challis as Director of the Cambridge Observatory.

In 1853 Adams communicated to the Royal Society his celebrated memoir on the secular acceleration of the Moon's mean motion. Halley was the first to detect this acceleration by comparing the Babylonian observations of eclipses with those of Albategnius and of modern times, and Newton referred to his discovery in the second edition of the "Principia." The first numerical determination of the value of the acceleration is due to Dunthorne, who found it to be about 10″ in a century. Tobias Mayer obtained the value 6″·7, which he afterwards increased to 9″. Lalande's value was nearly 10″. The discrepancies were due to the eclipses selected, the results derived from the different eclipses being inconsistent with one another. The history of the theoretical investigations relating to the acceleration may be summed up as follows:—In 1762 the French Academy proposed as the subject of their prize the influence of a resisting medium upon the movements of the planets. The prize was won by Bossut, who showed that the principal effect of such a medium would be an acceleration in their motions, which would be much more sensible in the case of the Moon than in that of the planets. In 1770 the question proposed was whether the theory of gravitation could alone explain the acceleration. Euler obtained the prize, but he was unable to discover any term of a secular character, and concluded that the force of gravitation would not account for this inequality. The subject was proposed again in 1772, Euler and Lagrange sharing the prize between them. The former came to the same conclusion as before, attributing the acceleration to a resisting medium; the latter did not carry the application of his formulæ so far as to complete the investigation. The prize was again offered for the same subject in 1774, the competitors being required to examine whether the fact that the Moon appeared to have a secular acceleration, while there was no sensible effect of this kind in the case of the Earth, could be explained by the theory of gravitation alone, taking into account not only the action of the Sun and the Earth upon the Moon, but also the action of the other

planets, and even the non-spherical figure of the Moon and Earth. The prize was awarded to Lagrange, who, after showing that none of the causes proposed would suffice to explain the secular variation of the Moon, concluded that, *if this variation is real*, it must be produced in some other manner, such as by a resisting medium. But as the existence of such a medium was not confirmed by the motions of the other planets, and was even contradicted by the motion of *Saturn*, which seemed to show a retardation, Lagrange expressed doubts with respect to the reality of the lunar acceleration, resting as it does on observations of eclipses in very remote ages. The next investigation relating to the subject is by Laplace, who showed that the acceleration could be accounted for by supposing that the transmission of the force of gravitation was not instantaneous, but that the rate of propagation was about eight million times that of light. Some years later, however, Laplace unexpectedly discovered the true gravitational cause of the acceleration. While working at the theory of *Jupiter's* satellites, he remarked that the secular variation of the eccentricity of *Jupiter's* orbit produced secular terms in their mean motions. Applying this result to the Moon, he found that the secular variation of the eccentricity of the Earth's orbit produced on the Moon's motion a secular term which agreed very well with the value assigned to it by observation; he found also that the same cause produced secular terms in the motion of the Moon's node and perigee. This result was communicated to the French Academy in November, 1787, and the memoir containing the details of the calculation was published in the following year. The Stockholm Academy of Sciences had already proposed in 1787 the secular variations of the Moon, *Jupiter*, and *Saturn* as the prize subject for 1791, but no essays being sent in, the prize was adjudged to Laplace for his memoir published in 1788.

Laplace's discovery was received with great applause, and the satisfactory explanation of so intractable a variation by means of the Newtonian principles, after so many years of fruitless attempt, was an important event in the history of astronomy. The honour of the discovery might very easily have belonged to Lagrange, for the formulæ given by him in a memoir published in 1783 would at once, if applied to the Moon, have produced Laplace's result. But Lagrange had found that, in the case of *Jupiter* and *Saturn*, these formulæ gave nearly insensible results, so that he did not extend the investigation to the other planets, or to the Moon, although the latter application would only have involved easy numerical substitutions, much simpler than those required for the principal planets.

In 1820, at the instigation of Laplace, the lunar theory was taken in hand afresh by Plana and Damoiseau, the approximations being carried to an immense extent, especially by the former. Damoiseau calculated the acceleration numerically, and found it to be $10''\cdot72$. Plana's process was algebraical,

and he carried the series, of which Laplace had only calculated the first term, as far as quantities of the seventh order. By reducing to numbers the twenty-eight terms of this series he found 10″·58 as the complete value of the acceleration, for which the first term, which alone had been included by Laplace, gave 10″·18. Subsequently Hansen gave the values 11″·93 (1842), 11″·47 (1847), and in his tables published in 1857 the value 12″·18 was used. It does not seem clear, however, to what extent these values are to be regarded as theoretical determinations.*

Thus when Adams published his memoir in the *Phil. Trans.* for 1853 no suspicion had arisen that Laplace's discovery was not absolutely complete, and that the question of the acceleration had not been finally set at rest. In his short paper of only ten pages Adams shows that the condition of variability of the solar eccentricity introduces into the solution of the differential equations a system of additional terms which affect the value of the acceleration. He found that the second term of the series on which the acceleration depends was really equal to $\frac{3771}{64}m^4$, instead of $\frac{2187}{128}m^4$, as found by Plana. The former is more than three times as great as the latter, and the amount of the acceleration is greatly decreased by the correction of the error discovered by Adams. For some time the paper seems to have attracted no attention, but it then became the object of a long and bitter controversy. Plana, who was the person most concerned in the matter, published, in 1856, a memoir in which he admitted that his own theory was wrong upon this point, and he deduced Adams's result from his own equations. But shortly afterwards he retracted his admission, and, rejecting some of the new terms which he had obtained, arrived at a result which differed both from his original value and from Adams's. The question was in this state when Delaunay, by employing his own special method of treating the Lunar Theory and extending the investigation only to the fourth order, had the satisfaction of obtaining Adams's coefficient $\frac{3771}{64}$, a result which he brought before the French Academy in January, 1859. This caused Adams to communicate to the Academy, in the same month, the values which

* Hansen stated in 1866 (*Monthly Notices*, xxvi. p. 187) that he had never disputed the correctness of Adams's theory, but that he was not satisfied with "the development of the divisors into series." If this refers to the expansion of the acceleration-coefficient in powers of m, it should be noticed that Adams stated (vol. xxi. p. 15) that he had calculated the value of the acceleration by a method that did not require any expansion in powers of m, and found the result to be 5″·70. Hansen says that Adams's theory appeared too late to permit of his using it; "and it was well that it so happened, for I had already found by my own theory a coefficient which represents ancient eclipses as well as could be desired." It seems impossible to resist the conclusion that in this theory the new terms must have been omitted by Hansen, as they had been by Plana and Damoiseau.

he had obtained some time before for the terms in m^5, m^6, and m^7; and he pointed out at the same time that, when these terms were included, the value of the acceleration was reduced to $5''{\cdot}78$, and, inferring that the remainder of the series would be nearly equal to $0''{\cdot}08$, he concluded that the total value of the acceleration was about $5''{\cdot}70$. Soon afterwards Delaunay carried his approximation as far as terms of the eighth order, and by reducing the forty-two terms in the analytical expression to numbers he obtained the value $6''{\cdot}11$. Delaunay's result, which was communicated to the Academy in April, 1859, confirmed the accuracy of Adams's values of the terms in m^5, m^6, and m^7, and also those of $m^2 e^2$, and $m^2 \gamma^2$, which Adams had communicated to him privately. A month after the publication of this paper Pontécoulant made a vigorous attack on the new terms introduced by Adams, which he said had been rightly ignored by Laplace, Damoiseau, Plana, and himself, as they had no real existence. He also objected that if the result of Adams were admitted, it would "call in question what was regarded as settled, and would throw doubt on the merit of one of the most beautiful discoveries of the illustrious author of the 'Mécanique Céleste.'" Shortly afterwards he communicated a paper to the *Monthly Notices* on "the new terms introduced by Mr. Adams into the expression for the coefficient of the secular equation of the Moon," in which he characterised the mathematical process by which these terms had been obtained as 'une véritable supercherie analytique.'" It would appear that Le Verrier did not accept Adams's value, for in presenting a note by Hansen to the Academy in 1860 he states that Hansen's tables afford an irrefragable proof of the accuracy of the value $12''$ which is there attributed to the acceleration. Referring then to the fact that according to Delaunay the secular acceleration should be reduced to $6''$, he proceeds: "Pour un astronome, la première condition est que ses théories satisfassent aux observations. Or la théorie de M. Hansen les représente toutes, et l'on prouve à M. Delaunay qu'avec ses formules on ne saurait y parvenir. Nous conservons donc des doutes et plus que des doutes sur les formules de M. Delaunay. Très certainement la vérité est du côté de M. Hansen."

In the *Monthly Notices* for April, 1860, Adams replied to his objectors, pointing out simply and clearly the errors into which they had fallen. He mentions that before publishing his memoir of 1853 he had obtained his result by two different methods, and that he had subsequently confirmed and extended it by a third. In a series of letters addressed to Lubbock in June, 1860, Plana began by objecting to Adams's value of the term in m^4, but he soon admitted its accuracy. Lubbock also was led to apply his own formulæ to the question, and he too arrived at Adams's result. Another calculation was made by Cayley, who, by an entirely different method, also obtained the same result. As Pontécoulant still continued his reiterated attacks upon the accuracy of the new

terms, Cayley's calculation was printed *in extenso* in the *Monthly Notices*, where it occupies fifty-six pages. Delaunay had also made another calculation, in which, by following the method indicated by Poisson in 1833, he was led to the same value. The coefficient of m^4 had also been verified in 1861 by Donkin, who used Delaunay's method of the variation of the elements. Thus Adams's value of the term in m^4 was obtained by himself in three ways, by Delaunay in two ways, and by Lubbock, Plana, Donkin, and Cayley. Pontécoulant continued his attacks with no abatement of violence in the *Comptes Rendus*. Ultimately he abandoned Plana's value and obtained one of his own, which differed both from Adams's and Plana's.

The whole controversy forms a very extraordinary episode in the history of physical astronomy; the indifference with which the memoir of 1853 was at first received, in spite of the interest and importance of the subject, being followed by the violent controversy which resulted in so many independent investigations by which Adams's result was confirmed. It is not known why Laplace did not carry the calculation beyond the term in m^2; but it may be supposed that he regarded the subsequent terms as not likely to modify the value of the first term to any considerable extent. Damoiseau's and Plana's theories passed under the review of Laplace, and may be regarded as having received his sanction. Thus Adams's result not only unsettled a matter which after years of difficulty and struggling had apparently received its full and final explanation, but it detracted from the completeness of a discovery which had long been regarded as one of the greatest triumphs of Laplace's genius. Although the point in dispute was one entirely relating to the mathematical solution of differential equations, in which observation in no way entered, there can be no doubt that the fact that Plana's result agreed with observation, while Adams's did not, created in the minds of many a presumption against the accuracy of the latter. This view was certainly taken by Le Verrier in the passage quoted above, and it seems also to have influenced Hansen. It is curious that it should have been possible for so much difference of opinion to exist upon a matter relating only to pure mathematics, and with which all the combatants were fully qualified to deal, as is clearly shown by their previous publications. The whole controversy illustrates the peculiar nature of the lunar problem, and of the analysis by means of which the results are reached. The complete solution being unattainable by any of the methods which have as yet been applied, the skill of the mathematician is shown in selecting from a vast number of terms those which will produce a sensible influence in that particular portion of the complete solution which is under consideration.

A most admirable account of the whole discussion was given by Delaunay in the Additions to the *Conn. des Temps* for 1864, in which the place occupied by Adams's memoir in the history

of gravitational astronomy is so well summed up that it may be permissible to quote the passage in its entirety :—

" L'apparition du mémoire de M. Adams a été un véritable événement : c'était toute une révolution qu'il opérait dans cette partie de l'astronomie théorique. Aussi le résultat qu'il renfermait fut-il vivement attaqué ; on ne voulait pas l'admettre, et on ne manquait pas de raisons à donner pour cela. Il est, disait-on, en désaccord complet avec les observations ; il ne tend à rien moins qu'à enlever à Laplace l'honneur d'une de ses plus belles découvertes ; il est basé d'ailleurs sur une analyse fautive et erronée. Mais parmi toutes ces raisons il n'y en avait pas une bonne ; et la persistance avec laquelle elles ont été présentées et soutenues a produit un effet diamétralement opposé à celui qu'on en attendait : les confirmations de ce résultat tant contesté se sont accumulées à un tel point, qu'il serait difficile de trouver dans les sciences une vérité mieux établie que ne l'est maintenant celle que M. Adams a mise en avant le premier dans son mémoire de 1853. Toutes les objections qui avaient été formulées sont tombées d'elles-mêmes. L'analyse déclarée *fautive et erronée* a été reconnue exacte. L'accord ou le désaccord du résultat théorique avec les indications fournies par les observations n'a plus été regardé comme un moyen de contrôler l'exactitude de ce résultat théorique. Si le désaccord annoncé existe bien réellement, on en conclut simplement que la cause assignée par Laplace à l'accélération séculaire du moyen mouvement de la Lune ne produit pas seule la totalité du phénomène et on ne trouve dans ce désaccord rien qui soit de nature à amoindrir la découverte de l'illustre géomètre français."

These sentences derive additional interest from the fact that they were written by one who was himself the author of the most comprehensive and elegant method by which the lunar problem has ever been treated, and who was the first to recognise the accuracy of Adams's result. In 1866 the Gold Medal of the Society was awarded to Adams for his contributions to the development of the Lunar Theory, the address on the occasion being delivered by De la Rue. In the preparation of this very able address, which contains an excellent history of the problem of the secular acceleration, De la Rue had the invaluable assistance of Delaunay. To complete the account of Adams's connection with the secular acceleration, it should be stated that in 1880, thirty-seven years after Adams's memoir, Airy communicated to the Society a paper on the theoretical value of the acceleration (*Monthly Notices*, vol. xl. p. 368), in which he obtained the value of $10''{\cdot}1477$. At the next meeting of the Society Adams pointed out that in Airy's method of treatment certain terms were omitted, the effect being that the expression for the coefficient was reduced to its first term, so that the result necessarily agreed with Laplace's. Subsequently, taking into account these terms, Airy obtained the value $5''{\cdot}4773$. Adams took the occasion of the matter being thus

raised again to communicate to the Society the investigation of the acceleration which he had been in the habit of giving in his lectures.

In the *Monthly Notices* for April 1867 he published an account of the results he had obtained with respect to the orbit of the November meteors. Professor H. A. Newton had concluded that these meteors belong to a system of small bodies describing an elliptic orbit about the Sun, and extending in the form of a stream along an arc of that orbit, which is of such a length that the whole stream occupies about one-tenth or one-fifteenth of the periodic time in passing any particular point. He showed that the periodic time of this group must be either 180·0 days, 185·4 days, 354·6 days, 376·6 days, or 33·25 years, and that the node of the orbit must have a mean motion of 52″·4 with respect to the fixed stars. Soon after the remarkable display of the November meteors in 1866 Adams undertook the examination of this question. From the position of the radiant-point observed by himself he calculated the elements of the orbit of the meteors, starting with the supposition that the periodic time was 354·6 days, the value which Professor Newton considered to be the most probable one. The orbit which corresponds to this period is very nearly circular, and he found that the action of *Venus* would produce an annual increase of about 5″ in the longitude of the node, that of *Jupiter* about 6″, and that of the Earth about 10″. Thus the three planets, which alone could sensibly affect the motion of the node would produce about 12′ in 33·25 years. The observed motion of the node is about 29′ in 33·25 years, which is therefore inconsistent with a periodic time of the meteors about the Sun of 354·6 days. If the periodic time were supposed to be about 377 days, the calculated motion of the node would differ very little from that in the case already considered, while if the periodic time were a little greater or a little less than half a year, the calculated motion of the node would be still smaller. Hence, of the five possible periods indicated by Professor Newton, four were incompatible with the observed motion of the node, and it only remained to examine whether the fifth period of 33·25 years would give a motion in accordance with observation. In order to determine the secular motion of the node in this orbit the method given by Gauss in his memoir "Determinatio Attractionis &c." was employed. By dividing the orbit of the meteors into a number of small portions, and summing up the changes corresponding to these portions, the total secular changes of the elements produced in a complete period of the meteors was determined, the result being that during a period of 33·25 years, the longitude of the node is increased by 20′ by the action of *Jupiter*, nearly 7′ by the action of *Saturn*, and about 1′ by that of *Uranus*. The other planets were found to produce scarcely any sensible effects, so that the entire calculated increase of the longitude of the node is about 28′, according very closely with the observed amount of

39′, and leaving no doubt as to the correctness of the period of 23·25 years. In order to obtain a sufficient degree of approximation it was requisite to break up the orbit of the meteors into a considerable number of portions, for each of which the attractions of the elliptic rings corresponding to the several disturbing planets had to be determined. These calculations were therefore of necessity very long, although a modification of Gauss's formula was devised which greatly facilitated its application to the actual problem. Subsequently certain parts of the orbit of the meteors were subdivided into still smaller portions, with the view of obtaining a closer approximation. Unfortunately the mathematical investigations which Adams carried out on this subject have not been published. They exist among his papers, together with a very great amount of numerical work connected with the calculations, and seem to be in a fairly complete state. It is hoped, therefore, that there will not be much difficulty in preparing them for press.

In 1877 Mr. G. W. Hill published a memoir on the motion of the Moon's perigee, in which he calculated that part of c which depends only upon m to fifteen places of decimals by a new method in which the expansion in powers of m was avoided, the numerical value of c being obtained by means of an infinite determinant. The publication of this memoir led Adams to communicate to the Society in November 1877 a brief notice of his own work in the same field, in which, after congratulating Mr. Hill upon his investigation, he mentions that his own researches had followed in some respects a parallel course. In particular he remarks that the differential equation for z, the Moon's coordinate perpendicular to the ecliptic, presents itself naturally in the same form as that to which Mr. Hill had so skilfully reduced his differential equations. In solving this equation, which was therefore of Mr. Hill's standard form, he fell upon the same infinite determinant as that considered by Mr. Hill, and developed it in a similar manner in a series of powers and products of small quantities, the coefficient of each such term being given in a finite form. This development was continued as far as the terms of the fourth order in 1868; and in 1875, when he resumed the subject, the approximation was extended to terms of the twelfth order, which is the same degree of accuracy as that to which Mr. Hill had carried his researches. On making the reductions requisite to render the two results comparable, he found that they were in agreement with the exception of one of the terms of the twelfth order, and that this discrepancy was due to a simple error of transcription. He states that the calculations by which he had found the value of the determinant were very different in detail from those required by Mr. Hill's method, but that he had not had time to copy them out from his old papers and put them in order. In this communication, therefore, he confined himself to making known the result which he had obtained for the motion of the Moon's node. After giving an

outline of the method pursued, including the equation derived from the infinite determinant, he arrives at the formulæ by means of which the value of g, as dependent only upon m, was obtained to fifteen places of decimals.

It is difficult to appreciate too highly the mathematical ability shown by Adams and Hill in devising methods which did not require expansion in powers of m, and which yielded with such wonderful accuracy these values of g and c. Apart, however, from the mathematical and astronomical interest of the researches themselves, the coincidence of methods and ideas is very striking. But for the publication of Hill's memoir it is probable that no account of these results of Adams's would have been published in his lifetime, and it is not unlikely that he would never have put into writing his views on the mathematical treatment of the lunar problem which give additional interest to this short paper. As far back as 1853, in his memoir upon the secular acceleration, he mentioned that the new terms in the expression of the Moon's coordinates occurred to him some time before, when he was engaged in thinking over a new method of treating the lunar theory, and it is well known that the theory itself, or problems connected with it, constantly occupied his attention. In this paper of 1877 he states that he had long been convinced that the most advantageous mode of treatment is by first determining with all possible accuracy the inequalities which are independent of e, e', and γ, and then in succession finding the inequalities which are of one dimension, two dimensions, and so on with respect to these quantities. Thus, the coefficient of any inequality in the Moon's coordinates would be represented by a series arranged in powers and products of e, e', and γ; and each term in this series would involve a numerical coefficient which is a function of m alone, and which admits of calculation for any given value of m without the necessity of developing it in powers of m. This method is particularly advantageous when the results are to be compared with those of an analytical lunar theory such as Delaunay's, in which the eccentricities and the inclination are left indeterminate, since each numerical coefficient admits of a separate comparison with its analytical development in powers of m. He mentions also that, many years before, he had obtained the values of the inequalities independent of the eccentricities and inclination to a great degree of approximation, the coefficients of the longitude expressed in circular measure, and those of the reciprocal of the radius vector, or of the logarithm of the radius vector, being found to ten or eleven places of decimals.

We thus see that Adams preferred to treat the lunar theory as far as possible by means of its special problems; and this was also the method which he followed in his Cambridge lectures. Mr. R. A. Sampson, Fellow of St. John's College, Cambridge, who has been making a careful examination of Adams's manuscripts, states that he believes that the investigations he has left will

suffice to form what will practically be a treatise on the lunar theory intermediate to the existing text-books and such complete theories as those of Plana and Delaunay. The manuscripts already put in order by Mr. Sampson contain the development of the infinite determinant and the other researches referred to in this paper.

The *Monthly Notices* for June, 1878, contains a short paper by Adams on a property of the analytical expression for the constant term in the reciprocal of the Moon's radius vector. Plana had found that the coefficients of e^2 and γ^2 in this term vanished when account was taken of terms involving m^2 and m^3, and Pontécoulant, who carried the development further, had found that this destruction of the terms in the coefficients still continued when the terms involving m^4 and m^5 were included. Thinking it probable that these cases in which the coefficient had been observed to vanish were merely particular cases of some more general property, Adams was led to consider the subject from a new point of view, and, so far back as 1859, he succeeded in proving that not only did these coefficients necessarily vanish identically, but that the same held good also for coefficients which were much more general, so that the coefficients of $e^2e'^2$, $e^2e'^4$, &c. $\gamma^2e'^2$, $\gamma^2e'^4$, &c. were also identically equal to zero. Further reflection on the subject led him in 1868 to obtain a simpler and more elegant proof of the property in question. He also found subsequently, in 1877, some remarkable relations connecting the coefficients of e^4, $e^2\gamma^2$, and γ^4. Adams himself remarks that the theorem "is remarkable for a degree of simplicity and generality of which the lunar theory affords very few examples." We thus see that a striking result—and one moreover which admitted of being isolated from the rest of the lunar theory—was obtained in 1859, but was not published till nearly twenty years afterwards, although in the meantime he had obtained another and more satisfactory proof. This illustrates the disinclination that Adams seems always to have felt to prepare his work for publication; a disinclination which was mainly due to his desire to obtain a still higher degree of simplification or perfection. The discovery of the additional relations in 1877 shows that his attention was at that time still occupied with the theorem of 1859.

Space does not permit of any more extended account being given of Adams's published astronomical writings, and it would be of little use to mention titles unaccompanied by some description of the contents of the papers. The shorter papers deserve much more detailed notice than might at first sight seem necessary, not only because they frequently consist wholly of results derived from laborious researches, but also because they afford glimpses of the nature and extent of the work with which he was occupied. For forty-five years his mind was constantly directed to mathematical research, relating principally to astronomy; and it is evident that what he had accomplished is very

inadequately represented by what has been published. It is also noticeable that so few of his papers should have appeared quite spontaneously: it frequently happened that he was incited to give an account of something which he had done himself—probably years before—by the publication of a paper in which the same ground was partially covered by some other investigator; in other cases he was called upon to correct some misapprehension which was leading others astray.

As already stated, there can be no doubt that he constantly allowed himself to postpone the immediate publication of his researches, with the intention of effecting improvements in the processes and mode of representing the subject, or of attaining to an even more accurate result. A striking instance of this innate craving for perfection is afforded, even as early as 1845, by his calculation of the second orbit of the new planet. No able mathematician who is engaged upon a fruitful research can continually defer publication with impunity: the subject opens before him; his views expand; the earlier results, so interesting at the moment of discovery, lose their charm in comparison with the problems still unsolved and the novel vistas of thought opened out by them; and the rearrangement and rewriting of the old work—always an irksome task—become intolerable when later and still unfinished developments on the same subject are exciting the mind. In Adams's case the difficulty of satisfying himself, and reaching his own standard of completeness, also contributed to his apparent reluctance to publish investigations to which he was known to have devoted much time, and which were anxiously awaited; such, for example, as his work upon *Jupiter's* satellites. Those who knew him will remember his words when pressed, "I have still some finishing touches to put to it." It does not appear that he ever made any serious attempt to put his longer investigations in order for press, though it is known that occasionally, as his manuscripts on the different subjects increased in bulk, the feeling would come over him that it was time for him to do so. Although there is no similarity between the simple and easy style of Adams's writings and the cold severity of Gauss's, there is a certain resemblance in their mode of work. Each had the same dislike to early or incomplete publication, and "Pauca sed matura" might have been the motto of both. In beginning a new research, Adams rarely put pen to paper until he had carefully thought out the subject, and when he proceeded to write out the investigation he developed it rapidly and without interruption. His accuracy and power of mind enabled him to map out the course of the work beforehand in his head, and his mathematical instinct, combined with perfect familiarity with astronomical ideas and methods, guided him with perfect safety through the intricacies and dangers of the analytical treatment.*

* This method of working characterised him from the first, for in his Tripos Examination it was noticed that "in the problem papers, when every-

He scarcely ever destroyed anything he wrote, or performed rough calculations; and the manuscripts which he has left are written so carefully and clearly that it is difficult to believe that they are not finished work that has been copied out fairly. The sheets are generally dated, and during many years he kept a diary of the work he had done each day, which will be of the greatest use in the arrangement of his papers for publication.

His contributions to pure mathematics show the same power and excellence, and, as the subject affords greater opportunities for the display of elegance and style, they indicate even more plainly the attention he bestowed upon the form of his results, as well as upon the substance. A paper communicated to the Royal Society in 1878 may be specially noticed, in which an expression is given for the product of two Legendrian coefficients, and for the integral of the product of three. The extent of his mathematical interests is perhaps best seen by looking over the series of papers which he set in the Smith Prize Examination. These questions, which cover a wide field of mathematics, clearly indicate the bent of his mind and his favourite subjects of study: they are also noticeable for a high degree of finish, which is very uncommon in examination questions.

Like Euler and Gauss, he took very great pleasure in the numerical calculation of exact mathematical constants. We owe to him the calculation of thirty-one Bernoullian numbers, in addition to the first thirty-one which were previously known. The first fifteen are due to Euler, the next sixteen were calculated by Rothe, the whole thirty-one being given in vol. xx. of Crelle's Journal. Making use of Staudt's very curious theorem with respect to the fractional part of a Bernoullian number, Adams calculated all the numbers from B_{31} to B_{62}. The results were communicated to the British Association at the Plymouth meeting in 1877, and were also published in vol. lxxxv. of Crelle's Journal. A much fuller account of the work, which was very considerable in amount, appeared in an appendix to vol. xxii. of the "Cambridge Observations," where the process of calculation of the first, B_{32}, and of the last, B_{62}, is given in detail. Adams proved that if n be a prime number other than 2 or 3, then the numerator of the nth Bernoullian number is divisible by n. This afforded a good test of the accuracy of the work.

Having thus at his command the values of sixty-two Bernoullian numbers, he was tempted to apply them to the calculation of Euler's constant. For this purpose, not only the Bernoullian

one was writing hard, Adams spent the first hour in looking over the questions, scarcely putting pen to paper the while. After that he wrote out rapidly the problems he had already solved 'in his head.'" It may be here mentioned that in this examination he received more than double the marks of the Second Wrangler. This affords striking evidence of Adams's mental powers, for he was not a rapid writer.

numbers, but also the values of certain logarithms and sums of reciprocals were required. He accordingly calculated the values of the logarithms of 2, 3, 5, and 7 to 263 (afterwards extended to 273) decimal places, and by their means obtained the value of Euler's constant to 263 places. He also calculated the value of the modulus of the common logarithms to 273 places. The papers containing these results appeared in the "Proceedings" of the Royal Society for 1878 and 1887. Anyone who has had experience of calculations extending to a great many decimal places is aware of the difficulty of manipulating with absolute accuracy the long lines of figures; but this was an enjoyment to Adams, and the work, as carried out with consummate care and neatness, in his beautiful figures, is an interesting memorial of the patience and skill that he devoted to any work upon which he was engaged.

Some may think that the portion of his own time occupied by these calculations might have been more advantageously spent; but there is a charm of its own in carrying still further the determination of the historic constants of mathematics, which has exercised its attraction over the greatest minds. Those who feel the least possible interest in calculation for its own sake, and even dislike ordinary arithmetical computations, have been unable to resist the fascination of doing their share towards the calculation of the absolute numerical magnitudes which are so intimately connected with the foundations of the sciences dealing with abstract quantity. There is a special pleasure also in applying the resources of modern mathematics to obtain the values of the incommensurable constants to such an incredible degree of accuracy, and in verifying the distant figures by methods depending upon subtile principles and complicated symbolic processes of the absolute truth of which we thus obtain so striking an assurance.

Adams had the greatest possible admiration for Newton, and perhaps no one has ever devoted more careful and critical attention to his mathematical works, especially the "Principia." When Lord Portsmouth presented to the University, in 1872, the large mass of scientific papers which Newton left at his death, the arrangement and cataloguing of the mathematical portion of the collection were willingly undertaken by Adams. It was a difficult and laborious task, extending over years, but one which intensely interested him, and upon which he spared no pains. He found that these papers threw light upon the remarkable extent to which Newton had carried the lunar theory, the method by which he had obtained his table of refractions (showing that the formula known as Bradley's was really due to Newton), and the manner in which he had determined the form of the solid of least resistance. In several instances he succeeded in tracing the methods that Newton must have used in order to obtain the numerical results which occurred in the papers. The solution of the enigmas presented by these numbers written on stray

papers, without any clue to the source from which they were derived, was the kind of work in which all Adams's skill, patience, and industry found full scope, and his enthusiasm for Newton was so great that he had no thought of time when so employed. His mind bore naturally a great resemblance to Newton's in many marked respects, and he was so penetrated with Newton's style of thought that he was peculiarly fitted to be his interpreter. Only a few intimate friends were aware of the immense amount of time he devoted to these manuscripts or the pleasure he derived from them. In 1887, on the occasion of the bicentenary of the publication of the "Principia," he was asked by Trinity College to deliver a commemorative address. Unfortunately the state of his health prevented him from undertaking a task which he alone could have adequately performed; but, with the kindness which all who sought his help invariably received, he most freely placed all the stores of his knowledge at the disposal of the present writer, who was appointed in his stead.

He was frequently asked to undertake calculations in connection with eclipses or other astronomical phenomena, and he never hesitated to lay aside his own work in order to comply with such requests. Mr. Downing has written: "His readiness to help, and his magnificent ability to help, will long be remembered at the Nautical Almanac Office," and similar words might be used with reference to the invaluable assistance which he so generously gave in other quarters. Many generations of officers of our Society can testify to his constant willingness to serve the Society, both as a referee and as a contributor to the annual reports. These reports and notices often cost him much time and thought.

He was President of the Society for the second time in 1874–76, when the medal was awarded to D'Arrest and to Le Verrier. In 1870, as Vice-President, he delivered the address on the presentation of the medal to Delaunay, of whose general method of treating the lunar theory he had the greatest possible admiration. In 1881 he was offered the position of Astronomer Royal, which he declined. In 1884 he was one of the delegates for Great Britain to the International Prime Meridian Conference at Washington. This visit to America afforded him great enjoyment and gratification.

He received the honorary degree of D.C.L. from Oxford, of LL.D. from Dublin and Edinburgh, and of Doctor in Science from Bologna and from his own university. He was a correspondent of the French Academy, of the Academy of Sciences of St. Petersburg, and of numerous other societies.

As Lowndean Professor he lectured during one term in each year, generally on the lunar theory, but sometimes on the theory of *Jupiter's* satellites, or the figure of the Earth. During his tenure of the directorship of the Cambridge Observatory in 1870 a fine transit circle by Simms was added to its equip-

ment. This instrument has been employed in observing one of the zones of the "Astronomische Gesellschaft" programme. The zone assigned to the Observatory was that lying between 25° and 30° of north declination.

In 1863 he married Eliza, daughter of Haliday Bruce, Esq., of Dublin, who survives him.

The publication of his complete works has been undertaken by the Cambridge University Press. The first volume, which will be edited by his brother, Professor W. G. Adams, will contain the papers which have been already published, as well as the magnetic work. A memoir of Adams will also appear in this volume. The second volume will contain the lectures and such of the unpublished work as can be prepared for press.

Adams was a man of learning as well as a man of science, and his thoughts and interests were far from being restricted to astronomy and mathematics. He was an omnivorous reader, and, his memory being exact and retentive, there were few subjects upon which he was not possessed of accurate information. Botany, geology, history, and divinity, all had their share of his eager attention. He derived great enjoyment also from novels, and when engaged in severe mental work always had one on hand. Among his more marked tastes may be mentioned his love of early printed books. His collection, containing about eight hundred volumes, eighty of which belong to the fifteenth century, was bequeathed by him to the University Library at Cambridge. The works relate principally to mathematics or astronomy, theology, medicine, and the occult sciences; but he seems always to have bought any fine old book that took his fancy. He was so little given to talk about himself or his pursuits that probably but few of his friends were aware of his passion for black-letter books.

No one who knew him superficially, or who only judged by his quiet manner, could have imagined how deeply he was affected by great political questions or passing events. In times of public excitement (such as during the Franco-German War) his interest was so intense that he could scarcely work or sleep. His love of nature in all its forms was a source of never-failing delight to him, and he was never happier than when wandering over the cliffs and moors of his native county. Strangers who first met him were invariably struck by his simple and unaffected manner. He was a delightful companion, always cheerful and genial, showing in society but few traces of his really shy and retiring disposition. His nature was sympathetic and generous, and in few men have the moral and intellectual qualities been more perfectly balanced. An attempt to sketch his character cannot be more fitly closed than in the words of Dr. Donald McAlister, who knew him well, and attended him in his last illness:—

"His earnest devotion to duty, his simplicity, his perfect selflessness, were to all who know his life at Cambridge a perpetual

lesson, more eloquent than speech. From the time of his first great discovery scientific honours were showered upon him, but they left him as they found him—modest, gentle, and sincere. Controversies raged for a time around his name, national and scientific rivalries were stirred up concerning his work and its reception, but he took no part in them, and would generously have yielded to others' claims more than his greatest contemporaries would allow to be just. With a single mind for pure knowledge he pursued his studies, here bringing a whole chaos into cosmic order, there vindicating the supremacy of a natural law beyond the imagined limits of its operation; now tracing and abolishing errors that had crept into the calculations of the acknowledged masters of his craft, and now giving time and strength to resolving the self-made difficulties of a mere beginner, and all the time with so little thought of winning recognition or applause that much of his most perfect work remained for long, or still remains, unpublished."

He was suddenly attacked by severe illness at the end of October 1889, but he recovered sufficiently to resume his mathematical work in the usual way for several months. In June of the following year he was again attacked by an illness from which he never completely recovered, and he passed away on the early morning of January 21, 1892, after being confined to his bed for ten weeks. The funeral service took place in Pembroke College Chapel, and he was interred in St. Giles's Cemetery, on the Huntingdon Road. There were many who thought that his resting-place should have been in Westminster Abbey, and a royal wish was expressed to this effect; but it is perhaps more fitting that he should lie in this quiet graveyard close to the Observatory where he passed so many happy and peaceful years.

On February 20 a public meeting was held at St. John's College, Cambridge, with the view of taking steps to place a bust or other memorial of him in Westminster Abbey. The proceedings on this representative occasion bore eloquent testimony to the admiration and affection in which he was held by his friends, and to the widespread wish throughout the country for such a memorial to one who was not only a great but a good man. No suitable site for a bust could be found in the Abbey, but a medallion will be placed in an excellent position close to the grave of Newton. This medallion is being executed by Mr. Bruce Joy, who is also engaged upon a bust for presentation to St. John's College. It may be added that five years ago an excellent portrait was painted by Herkomer, which is now in the Combination Room of Pembroke College. J. W. L. G.

Charles Orchard Dayman was born 1803 July 9. In 1820 he went as a pensioner to St. John's College, Cambridge, of which he became a scholar, and in 1824 took his B.A. degree as third Senior Optime. He won in 1826, but did not accept, a

Platt Fellowship at his college, and was called to the Bar in 1829. He was a revising barrister for the South Devon boroughs and afterwards for South Wilts, and in 1856 was appointed a magistrate of the metropolitan police courts, which office he resigned in 1871. Having purchased an excellent refractor by Cooke of York of 5 inches aperture, and Smyth's "Celestial Cycle," he amused himself with a study of the heavens, and in or about 1858 he prepared for Mr. Stanford a new edition of the smaller celestial maps of the Society for the Diffusion of Useful Knowledge containing all the objects in the Cycle. His telescope became the property of his friend, the late Francis Barrow, F.R.A.S. He was one of the nineteen members of the old Spitalfields Mathematical Society who were elected Fellows of this Society on 1845 June 13, "without payment of the usual admission fees and annual contributions (or compositions in lieu thereof), the Mathematical Society having announced its resolution to transfer its valuable library, with its records and memorials, to the Royal Astronomical Society" (*Monthly Notices*, vol. vi. p. 25). Of the nineteen, one only now survives, two having died within the past year. Mr. Dayman did not contribute any papers to the Society. He died on 1892 January 22, in his 89th year. [The above, down to the words "Francis Barrow, F.R.A.S.," is literally transcribed from a sheet of note-paper in Mr. Dayman's handwriting, found among his papers after death. Mr. Dayman wrote the notice of his friend Mr. Chabot, also one of the Spitalfields Mathematical Society, printed in *Monthly Notices*, vol. xxix. p. 123; and this sheet of note-paper was probably written for the *Monthly Notices* in the event of his own death.]

ROBERT GRANT was born at Grantown-on-Spey, N.B., on 1814 June 17. His father, Mr. Robert Grant, was a much respected tradesman of that town. He received the elements of education at the endowed school, which was established by the Earl of Seafield, proprietor of the district, and which provided for instruction in the ordinary branches of education, including the elements of Greek and Latin, in order that the youth of the district should receive the preparatory course of instruction requisite for entering any of the Scottish universities. In this school young Grant exhibited early indications of being an intelligent youth, with more than usual precocity. At the age of nine he commenced the study of Latin, and soon made rapid progress in this and other subjects. But while enjoying the prospect of a promising boyhood, his studies were, at the age of thirteen, interrupted by a serious and long-continued illness, which for six of the most important years of his youth incapacitated him for all school-work. During this long period, when most young men are actively preparing for their future position in life, young Grant was helplessly confined to a bed of lingering sickness, and dependent solely on the affectionate care of his

relatives. After completing his nineteenth year, his health became comparatively restored, when he resolved to renew his former studies, becoming his own instructor. With no other assistance than what he could obtain from books, the young student devoted himself most assiduously to the study of Greek, Latin, French, Italian, and elementary mathematics, with an enthusiasm which the long blank in his career served only to increase. Astronomy was not forgotten, and Sir John Herschel's *Treatise on Astronomy* was a favourite book of study. His astronomical tastes at this time were much encouraged by the interest he took in the return of Halley's comet in 1835, and in the annular eclipse of the Sun, 1836 May 15, when young Grant was able to make his first astronomical observation. In this manner he gradually qualified himself for the high position he afterwards occupied as the honoured historian of the progress of physical astronomy.

When his health became permanently established, Mr. Grant entered upon a short course of study at King's College, Aberdeen, but, considering that there would be a better opening for his special talents in London, he resolved to avail himself of the advantages which a residence in the great metropolis would afford. Here, during the next four years, he obtained employment in the counting-house of an elder brother as a bookkeeper. But in his leisure hours he became a devoted reader of standard works on astronomy and mathematics. It was about this time that he first conceived the notion of writing a brief history of physical astronomy from the earliest ages to the middle of the nineteenth century. He had already accumulated a mass of material suitable for his purpose, but he resolved to defer the commencement of this work until he had had an opportunity of consulting the works on astronomy contained in the great public libraries of Paris. In 1845 he took up his residence in Paris, where he remained nearly two years, supporting himself by giving lessons in English. During the greater part of this time he had a great advantage in the use of the library of The Institute, a privilege he owed through an introduction by one of his pupils. He usually attended the courses of astronomical lectures delivered by Arago at the Observatory, and by Le Verrier at the Sorbonne, including the inaugural discourse of the latter on his appointment as one of the professors.

During the five years following his return to London, in 1847, Mr. Grant devoted most of his time to the preparation of his classic work, *History of Physical Astronomy*. Though still unknown to the leading astronomers, he had already made himself master of the details of most of the principal astronomical investigations, and through a happy personal introduction by Mr. Woodfall, the well-known printer, to Captain R. H. Manners, R.N., then one of the honorary secretaries, he was able to continue his researches by a frequent use of the library of this Society, a concession he has, more than once, gratefully acknow-

ledged. Fortunately, shortly after Mr. Grant's return from Paris, he was introduced to Mr. Robert Baldwin, who, at that time, was the enterprising publisher of an excellent series of works known under the title of "The Library of Useful Knowledge," which received much popular attention. Mr. Grant proposed to contribute to this series a concise history of the principal investigations and discoveries in astronomy which have helped to build up our present knowledge of the physical movements and aspects of the heavenly bodies; or, in his own words, "to exhibit a view of the labours of successive enquirers in establishing a knowledge of the mechanical principles which regulate the movements of the celestial bodies, and in explaining the various phenomena relative to their physical constitution which observation with the telescope has disclosed." The proposal was at once accepted by Mr. Baldwin, and the work was first published in separate parts, or numbers; but, after the issue of the ninth number, this form of publication was discontinued. The first part appeared in 1848 September. The complete work was not published until 1852 March, before which Mr. Grant had been elected a Fellow of this Society. Some of the early numbers of the work were submitted to Professor De Morgan and a few other astronomers, all of whom were at once struck with the accurate and comprehensive grasp of the various theoretical researches, especially by an author hitherto unknown, and it was easily perceived that all the original authorities were carefully consulted by him, and that an attentive consideration was given to each subject. Some of the personal disadvantages under which Mr. Grant laboured are very truly described in the following paragraph taken from the Annual Report of the Council, 1853 February:—

"During the past year Mr. Grant has completed his *History of Physical Astronomy*, a work the first numbers of which formed his introduction to the Society. It is very seldom that the Council are called upon to notice any work of so peculiar a merit. If Mr. Grant had possessed perpetual access to extensive libraries, and peculiar inducements to consult them; if he had passed many years in historical research, had matured his judgment by long habits of discussion with others of like pursuits, and had learned by small attempts how to venture on larger efforts, the production of a sustained history, of extent and matter such as he has published, would have excited admiration, and would have called forth some remark on the true secret of success in such undertakings. But when it is considered that the author had no more connection with libraries than anyone may command for the asking, and no peculiar calling to tempt him into research; that he has not reached middle life, and that his opportunities were furnished, as is understood, by the leisure of ill-health or convalescence; that he had, before the publication of his work, little or no sustained opportunity of communication with those who could have helped to direct his reading or form his judgment,

and that he never published anything whatever previously to the appearance of this well-conceived, well-executed, and greatly-wanted history, the Council, while they state that the work has taken a place among standard books of history from its first appearance, under circumstances which greatly enhance the merit of its author, congratulate the Society upon the prospect of numbering Mr. Grant among its executive members."

After a careful perusal of this remarkable history of the labours of astronomers from the remotest times, the reader cannot fail to be struck with its completeness, and with the rare skill and power displayed in the discernment of the salient points of some of the most difficult researches in astronomy, many of which, from their nature, are of a controversial as well as of an abstruse character. But, in most cases, the author has most scrupulously endeavoured to assign to each of the great men who had been working independently on the same line of research their proper share in the common labour. The President, the late Manuel J. Johnson, Radcliffe Observer, on presenting the Gold Medal of the Society to Mr. Grant, in 1856, very truly remarked, that "nowhere is this more conspicuous than in the discussion relative to the discovery of the planet *Neptune*. By a simple narration of facts he has placed the history of that great event in so clear and so true a light that I believe I am not wrong in saying he has gained an author's highest praise under such circumstances—the approval of both the eminent persons concerned."

In 1852 November Mr. Grant was requested by the Council to undertake the duty of editing the *Monthly Notices*, in succession to the Rev. R. Sheepshanks. His literary tastes encouraged him to introduce some new features in that publication, especially brief notices and abstracts of valuable astronomical papers that had recently appeared in the *Comptes Rendus*, *Astronomische Nachrichten*, and other scientific serials, including the *Memoirs* of different societies at home and abroad. These editorial notices were much appreciated at the time by the Fellows of the Society, and they were continued by him in successive volumes as additional records of astronomical research carried on outside the Society. Mr. Grant continued in charge of the *Monthly Notices* and *Memoirs* of the Society until his appointment by the Home Secretary, in 1859 November, to the important office of Professor of Astronomy and Director of the Observatory in the University of Glasgow, in the vacancy caused by the death of Professor J. P. Nichol. He, however, did not obtain the definite control of the Observatory until 1860 May. He was succeeded by Professor Cayley in the editorship of the Society's publications.

Professor Grant has communicated several interesting papers to the Society. One of these, published in 1853, contains an investigation of the correction to be applied to the apparent ellipticity of a planet, in consequence of the elevation of the Earth

above the plane of the planet's equator. In this important paper Professor Grant has clearly shown that his astronomical talents were not confined solely to the literature of astronomy. Of his other communications to the Society, we need only allude to a paper read at the 1871 December meeting, "On Telescopic Observations of the Phenomena seen in contiguity with the Moon's Limb during Eclipses of the Sun, and the Results which have been therefrom deduced." The principal object of this paper was to point out that the conclusions expressed by Professor Grant on p. 400 of his *History of Physical Astronomy*, relating to the origin and nature of the red sierra observed on the Moon's limb during total eclipses of the Sun, were actually derived from an inductive inquiry based upon a discussion of the observations of all former eclipses recorded in history. The portion of the *History of Physical Astronomy* containing Professor Grant's conclusions on the subject were published in the winter of 1850–51. At this time it was still an open question whether the corona and red prominences were solar or lunar phenomena. It is interesting therefore to note how decided Grant was in the opinion he had given in his book. "While engaged in this enquiry," he remarks, "I endeavoured to show that the phenomena observed during solar eclipses, whether corona, streaks or patches of light, or prominences great or small, are all solar phenomena. While the results of observation were either positively in favour of the solar aspect of the case, or adverse to the lunar aspect, there did not appear to exist a shadow of a proof in support of the lunar origin of the phenomenon." It was a great satisfaction to Professor Grant that, having been a member of the *Himalaya* eclipse expedition to Spain in 1860, he had had the opportunity of witnessing at Toloño the scarlet sierra of which he had given so plausible an interpretation ten years before.

On taking up his residence at the Glasgow Observatory in 1860, Professor Grant found that the only instruments at his disposal were a transit-circle by Ertel & Sons, of Munich, of six French inches aperture, a Dollond refractor of three inches aperture, a sidereal clock, and a few other instruments of minor importance. To these were added, in 1863, the Ochtertyre equatoreal by Cooke, of nine inches aperture, formerly belonging to Sir W. Keith Murray, and a small transit instrument of three inches aperture, the latter chiefly for educational purposes. The funds for the purchase of these instruments, and for the erection of the building in which the equatoreal is mounted, were obtained through the liberality of a few gentlemen, chiefly residents of Glasgow. The equatoreal was frequently employed by Professor Grant in the usual extra-meridian observations of comets, minor planets, and in measures of a selection of double stars, taken from Struve's *Mensuræ Micrometricæ*; but in later years the absorbing demands of the new star catalogue necessitated its use only for the observation of occasional phenomena.

In 1861 Professor Grant proposed to the Town Council of

Glasgow a scheme for controlling certain of the public clocks in the City and Port by a direct current of electricity from the Observatory, so that they might be regulated continuously to exhibit true Greenwich mean time. After some controversy on the subject, the Town Council decided to accept the proposal of Professor Grant, who at once adopted the plan of controlling invented by Mr. R. L. Jones, of Chester, which had been previously employed with success at Liverpool and other places. This system of control of the public clocks has been continued to the present time as a part of the daily duties of the Observatory.

In 1865 May Professor Grant, in co-operation with the Astronomer Royal, made a special series of observations for the determination of the difference of longitude between the observatories of Glasgow and Greenwich by an interchange of galvanic signals of star-transits on four simultaneous clear nights. The details of the observations are inserted in the *Monthly Notices* for 1865 December. Among his other miscellaneous work, Professor Grant favourably observed the great meteoric shower of *Leonids* on 1866 November 13, a large number of which supplied him abundant materials for establishing the position of the radiant point. He has contributed to the *Monthly Notices* the details of this great display, as well as of those observed on 1868 November 13, 1872 November 27, and 1885 November 27. He was also fortunate to observe, at the Glasgow Observatory, the ingress of the planet *Venus* during the transit of 1882.

Some reference should be made here to Professor Grant's valuable contribution to an important correspondence on the celebrated "Chasles" forgeries of the Pascal papers, which assisted more than any other in deciding the true character of these documents. Professor Grant, in the *Times* of 1867 September 20, admirably exposed, in the most conclusive manner, that the whole series of papers submitted to M. Chasles were, on the face of them, utterly fallacious. His argument was based upon certain numerical results contained in the so-called Pascal papers, and he shows clearly that these forgeries were concocted from corresponding numbers in the third edition of the *Principia*, published in 1726, Pascal having died in 1662.

One of the principal objects Professor Grant had in view from the beginning was the observation with the transit-circle of a selected list of stars, in order that their observed positions might be ultimately incorporated into a Glasgow Catalogue of Stars. It was his intention at first to confine the selection to the B.A. Catalogue, but he finally resolved to include in the list several thousands of telescopic stars, mostly taken from the first volume of Weisse's Bessel. The results of his more than twenty years' work with the transit-circle are contained in the "Catalogue of 6,415 Stars for the epoch 1870, deduced from observations made at the Glasgow University Observatory during the years 1860 to 1881." This excellent work, which was pub-

lished in 1883, is not only found useful in supplying sensibly accurate mean places of a large number of stars of the eighth and ninth magnitudes, suitable for employment as reference stars in connection with observations of minor planets and comets, but the places are sufficiently reliable for the determination of proper motions. In the introduction to this volume Professor Grant has determined the proper motions of 99 stars, which, with few exceptions, had previously escaped detection. The preparation of a work of such magnitude must necessarily involve an immense amount of observation and calculation in a well-equipped observatory, but when it is considered that this important catalogue is the outcome of an observatory provided with only a scanty allowance for one assistant, it is difficult to form an adequate conception of the heavy responsibility which must have fallen on Professor Grant during the progress of the calculations and the arrangement of the work for the press.

A Second Glasgow Catalogue of 2,156 stars, in the preparation of which Professor Grant took a great interest, was published a few weeks only after his death. This catalogue contains the mean places of all the stars observed between 1886 and 1892, with the object of explaining certain inconsistencies in the former catalogue, or where there was any suspicion of proper motion shown by a comparison which Professor Grant instituted between the places of the W. B. stars in the First Catalogue, and the corresponding places of Bessel and Lalande. In the introduction he gives the details of 192 new determinations of proper motion. He personally revised the greater portion of this work while passing through the press; but his health must have been failing fast when he wrote in the early autumn that his assistant, Mr. Connell, "was especially helpful to me in the final stage of the catalogue passing through the press, when, in consequence of severe illness by which I was overtaken at the time, the aid of an assistant familiar with the whole details of the work was indispensable." Though still an invalid, Professor Grant had the gratification of completing the introduction, and he continued to examine and correct all the proof-sheets of the catalogue, even down to the last sheet, which he looked over on the morning of his death.

In 1868 the Glasgow Observatory was chosen as one of the stations at which systematic meteorological observations were made in connection with the Meteorological Office in London. Professor Grant was greatly interested in these observations, and faithfully performed all that was required. In 1883 some of the stations, including Glasgow, were closed, but through his strenuous exertions he prevailed upon the Town Council and the Clyde Trust to provide the pecuniary assistance necessary to continue the observations as before.

Professor Grant's intimate knowledge of the French language did good service in the translation of Arago's well-known *Astronomie Populaire*, which was edited by him and Admiral

W. H. Smyth, and published, with editorial foot-notes, in 1858. He also assisted in the translation of Arago's corresponding volume of biographies of eminent scientific men. About this time he had the permission of the Astronomer Royal to attach himself to the Royal Observatory, where he obtained some practical experience in making astronomical observations. This course of instruction extended over nearly twelve months, and the practice he obtained in the use of the instruments was found to be of considerable service to him in after years in his own observatory.

In addition to his astronomical papers printed in the *Monthly Notices*, Professor Grant was an occasional contributor to the *Astronomische Nachrichten*, the *Comptes Rendus*, the *Proceedings of the Philosophical Society of Glasgow*, Charles Knight's *English Cyclopædia*, and other works. He has also delivered courses of astronomical lectures on several occasions, the most important of which were those delivered in 1854 and 1855 at the London Institution, Finsbury Circus, and in 1868, 1869, and 1870 at the Royal Institution. Shortly after, he delivered three similar courses of lectures to ladies at the University of Glasgow.

The honorary degree of M.A. was conferred on Professor Grant in 1855 by the University of Aberdeen, and that of LL.D. in 1865. On 1865 June 1 he was elected a Fellow of the Royal Society. During three years he filled the office of President of the Philosophical Society of Glasgow. As before stated, the Gold Medal of the Royal Astronomical Society was awarded to him on 1856 February 8 for his *History of Physical Astronomy*.

On 1874 September 3 Professor Grant married Elizabeth Emma, daughter of the late A. C. Davison, of Newcastle, New South Wales, and co. Monaghan, Ireland, by whom he leaves one son and three daughters. Although he was the subject of so much physical weakness during his youth, he always appeared to his friends to be in the full enjoyment of health and vigour. He called on the writer at Blackheath in 1892 March, when all who saw him were surprised at the activity of mind and body exhibited by him on that occasion. His brightness was particularly marked when references were made to some pleasant reminiscences of mutual association with some valued astronomical friends long since passed away. For some time, however, it had been observed by his family that his health was visibly failing, and particularly so in the early summer months. He never really rallied again, though his strength was sufficient to allow him to take a continued interest in his work, and to examine and correct the proofs of his Second Catalogue, which was passing through the press during his last illness. For a period of three months preceding his decease he was seen to become gradually weaker, but his voice was as strong, and his mind as clear, to the last hour of his life as they ever had been. His friends hoped that a brief relaxation from his observatory work in the bracing air of his native Strathspey would restore

him for a time, but he had not been there long before his bodily weakness increased, and during the last few weeks he very gradually and peacefully faded away. The end came rather suddenly. He died at Grantown, on 1892 October 24, in the seventy-ninth year of his age.

Professor Grant was elected a Fellow of the Royal Astronomical Society on 1850 June 14, and was a member of the Council from 1853 to 1860. E. D.

JOHN HARTNUP was born at Somerset House, in the apartments of the Society, in 1841, when his father held the position of Assistant Secretary. In 1843 his father removed to Liverpool, having been appointed Astronomer to the Mersey Docks and Harbour Board, and the whole of Mr. Hartnup's life may be said to have been passed upon the banks of the Mersey. He was educated at the Royal Institution School, Liverpool, and at a private academy at Chester, and his scientific training seems to have been effected under his father's sole and careful supervision. He became assistant in the Liverpool Observatory, in 1863, shortly before the Observatory was removed from the Waterloo Dock to its present position at Bidston, and there he gave unremitting attention to those many experiments on chronometrical rates with which his father's name has been so long connected, and which have proved of such signal service to the mercantile marine.

When his father retired from the service of the Mersey Docks and Harbour Board, Mr. Hartnup succeeded him as director of the Observatory, and so remained until his death. His most valuable contributions to science have been his papers on chronometrical management, and his reputation must rest on these. He gave effective support and assistance to the Liverpool Astronomical Society, holding for some time the position of vice-president, and other scientific societies in Liverpool found in him a warm and cordial supporter. He was elected a Fellow of the Royal Astronomical Society on 1886 February 12.

On 1892 April 21 he was killed by falling from the roof of the Observatory, where he had mounted to make some meteorological observations. W. E. P.

THOMAS ARCHER HIRST was born at Heckmondwike (Yorkshire) on 1830 April 22, and was educated at the West Riding Proprietary School, Halifax. The acquaintance he there made with John Tyndall had a great influence on his future life. Tyndall went to Marburg University in 1847, and a visit paid to him there was sufficient to determine Hirst to migrate to that University, to study mathematics, physics, and chemistry. He graduated in 1852, presenting a dissertation on "Conjugate Diameters of the Ellipsoid." From Marburg he went to Göttingen, where he made the acquaintance of Gauss and worked at magnetism under Weber; and thence to Berlin. He was

recalled to England to succeed Tyndall at the Queenwood College, Hampshire, and remained there for three years; and in 1854 he married Anna, youngest daughter of Samuel Martin, Esq., of Loughorne, County Down, Ireland; but the delicate health of his wife necessitated a visit to the South of France during the winter of 1856-7, which was unfortunately unavailing, for Mrs. Hirst died on the return journey in Paris. Dr. Hirst then spent two years abroad, attending the lectures of eminent mathematicians (Chasles, Liouville, Lamé, Bertrand), and writing several memoirs. Early in 1860 he unexpectedly found employment in University College School, of which he was made head master on the death of Mr. Cook. It was during his five years' tenure of this appointment that he made experiments on teaching geometry apart from "Euclid"; and he was one of the founders (in 1871) of the Association for the Improvement of Geometrical Teaching, and its president for the first seven years. In 1865 Dr. Hirst was appointed Professor of Mathematical Physics in University College, London, and in 1867 Professor of Mathematics, in succession to De Morgan. In 1870 he accepted the newly-created appointment of Assistant Registrar in the University of London, in consequence of which he resigned not only his professorship, but his general secretaryship of the British Association, which he had held for four years. Early in 1873, when the Royal Naval College was founded at Greenwich, Dr. Hirst was appointed Director of Studies, which position he occupied until 1883, when ill-health compelled him to resign it, and pass much of his time abroad. He died on 1892 February 16.

Dr. Hirst was one of the original members of the London Mathematical Society (1861); was on its council 1864–1883; was treasurer for several years, and president 1872–1874. He was elected a Fellow of the Royal Astronomical Society in 1866, but never contributed any papers to the Society. He was elected Fellow of the Royal Society in 1861, was three times a member of its council, and twice one of its vice-presidents; and in 1883 he was awarded a Royal Medal. He was also a member of several other learned societies, British and foreign. His scientific work was chiefly confined to pure mathematics, and the excellence of its quality will be gathered from the uniform success which marked his career. Among his more important papers are those "On Equally Attracting Bodies" (*Phil. Trans.* 1857–8); "On Ripples and their Relation to the Velocity of Currents" (*Phil. Mag.*, 1861); "On the Volumes of Pedal Surfaces" (*Phil. Trans.*, 1863); "On the Quadric Inversion of Plane Curves" (*Proc. R.S.*, 1865); and many in the *Proceedings of the Mathematical Society*, 1869–90.

Joseph Kleiber, second son of Henry Kleiber, was born at St. Petersburg on 1863 December 15. He graduated at St. Petersburg University, and while privat-docent delivered lectures on "The Application of Mathematics to Social Phenomena," and

"The Theory of Probabilities." His studies were mainly directed towards astronomy, and he was with Professors Tacchini and Ricco on the river Viatka to observe the total solar eclipse of 1887 August 19. He completed his Russian degree in 1888 by a thesis on "The Method of Smoothing Series of Observations," but his studies having created in him a desire to learn something more of Cambridge mathematics, he came over to England in June 1888, and spent a year in Cambridge. There are many who will long remember this visit of a young Russian enthusiast, attracted from so far by the fame of their university, who worked with the might of a mathematical Hercules. He wrote a sketch of Cambridge life in the *European Messenger* (a Russian review). He returned to St. Petersburg in the autumn of 1889, and was married on October 6. He resumed lecturing at the St. Petersburg University, on the method of least squares and the theory of gravitation; but the symptoms of the fatal disease from which he died had already appeared. He became seriously ill in May 1891, and died from phthisis, at Nice, on 1892 February 12.

In his short scientific life he wrote thirty-two papers, two of which have been published since his death. Eleven of these deal with meteors and shooting stars, the most important being the "Catalogue of 918 Orbits of Meteor Streams from the Observations of Mr. W. F. Denning" (*Monthly Notices*, vol. li. No. 1), and the posthumous paper "On the Displacement of Radiants by the Attraction and Motions of the Earth" (*Monthly Notices*, vol. lii. No. 5). Eleven papers deal with probabilities and statistics in their application to astronomy and meteorology, one or two are on pure mathematics, and one or two on miscellaneous subjects.

He was elected a Fellow of the Society on 1889 December 13.

THOMAS LEE was born in the parish of Galston in the year 1818, and first came to Kilmarnock, which he afterwards made his home, as a boy of fourteen, to fill the post of commercial clerk. Four years later he went to London, where he still continued to be engaged in commercial pursuits. After visiting Paris and other cities he returned to Kilmarnock, and took up the profession of tuition, his first school being in Queen Street. When the appointment of mathematical and commercial master in the Kilmarnock Academy became vacant, the success and reputation Lee had already attained as a teacher caused him to be selected from a large number of candidates—a selection which his future career abundantly justified. He by no means confined his instructions to his pupils to their preparation for a business life, a work in which he was very successful, but took a great interest in training many of them in the higher branches of mathematics and astronomy, and secured for them more than a rudimentary knowledge of those sciences. He was greatly assisted in his astronomical teaching by the erection of the observatory in Morton Place, which was provided with two good reflecting telescopes and other astronomical instruments. This

observatory was built by the late Baillie Thomas Morton, whose daughter Mr. Lee married in 1841. He retired from public educational life in 1876, but as session clerk, an office to which he had been appointed in 1872 on the death of his son-in-law, Mr. Smith, and which he held up to the time of his death, he still took part in the public life of the town, and the celebration of his golden wedding-day in 1891 was made an occasion by his fellow-workers in the Kirk Sessions and his many friends for testifying to the regard in which he was held by them. He was a man of great information, clear intellect, keen scientific spirit, and fine personal character, and was widely respected. He was elected a Fellow of this Society 1856 June 13. He died 1892 January 24, leaving a widow, two sons, and four daughters.

William Edwards Michell, of the Fort, Newquay, was the son of the late Mr. William Michell, Registrar of the Court of the Vice-Warden of the Stannaries of Cornwall and Devon. He was born at Truro, 1840 March 14, and was educated at private schools and at Christ Church, Oxford. Inheriting from his father a considerable property at Newquay, on the north coast of Cornwall, Mr. Michell soon became interested in its local affairs, and for many years he was one of the foremost in promoting the various improvements which have transformed this hitherto unknown seaside village into a place of popular resort. For more than thirty years he was an officer in the Royal Cornwall and Devon Miners' Artillery Militia, and during the last ten years its lieutenant-colonel in command. He was also a magistrate for the county of Cornwall, and a member of the County Council. Colonel Michell was interested in the investigations of the probable origin of the local antiquities of Cornwall, and he has contributed papers on "Camps and Tumuli," and other archæological remains to the *Journal of the Royal Institution of Cornwall.* He also took a personal interest in the progress of astronomy, and in the proceedings of this Society, though he had few opportunities for attending the meetings. He had shown symptoms of declining health during the autumn, and in October he left Newquay to obtain the special advice of a London physician. His friends entertained great hopes of his recovery, but he never permanently rallied, and died at Woolwich on 1892 November 5, in the fifty-third year of his age.

Colonel Michell was elected a Fellow of the Society on 1874 June 12.

The Rev. Isaac Vale Mummery was born in 1812 at Canterbury, and died in 1892 October 2. He was educated for the ministry at Coward College, and was successively settled as pastor at Tunbridge, Ratcliffe, and Bethnal Green. A brief account of his work will be found in the *Evangelical Magazine* for 1892 November. He was elected a Fellow at the Annual

General Meeting, 1853 February 11. He did not contribute any papers to the Society, but on 1873 June 13, the "Rev. J. V. Mummery presented to the Society a fine photograph from a painting of the late Mrs. Somerville" (*Monthly Notices*, xxxiii. p. 461). The printer's error, "J. V." for "I. V." in the initials, also occurs in the note of his election.

ANKITAM VENKATA NURSING ROW was born in the year 1827. He comes of an ancient stock settled on the banks of the Krishna. Mr. Nursing Row's father was Diwan to the Nawab of Masulipatam, and his uncle a Dubash of the East India Company at Ganjam. Mr. Nursing Row lost his father when an infant; so he was brought to Vizagapatam, and brought up under the care of his maternal grandfather. His education was entrusted at first to Mr. Porter, and then to the Rev. J. Hay, M.A., D.D., the father of modern education in the Northern Circars. Mr. Nursing Row entered the service of the East India Company when he was young, and early rose to the position of a deputy collector; but his wife inherited a large estate from her mother, and he resigned his connection with the public service for the purpose of managing the estate. He found connected with it a small observatory, provided with a transit instrument, erected by his father-in-law, Mr. G. V. Jugga Row, an ingenious and wealthy Zemindar, who invented a pluviometer. Finding the management of the estate afforded him plenty of leisure, Mr. Nursing Row devoted himself to the study of astronomy. He learnt the rudiments of the science from Dr. Hay, and, in correspondence with eminent English astronomers, who kindly gave him a good deal of help, began to develop the institution left by his father-in-law. He had a new observatory built in 1874, and provided it with a 6-inch equatoreal instrument, a transit circle, and a sidereal clock. He was appointed Honorary Meteorological Reporter to the Government of India for Vizagapatam. The Government evening time-gun at this station having been discontinued on 1871 September 20, Mr. Nursing Row offered to bear the expenses of the firing, which the Government of Madras allowed as a special case, and this useful institution has been maintained ever since. He founded a photographic studio in this town. He was elected Fellow of the Royal Astronomical Society in 1871, and of the Royal Geographical Society in 1872. The dearest wish of his heart was to provide the Observatory with the means for photographing the sky. For this purpose he obtained celestial photographic instruments, but died on 1892 June 18, before he could complete the arrangements.

BENJAMIN SCOTT was born in 1814, and was the son of Mr. Benjamin Scott, who at that time was a junior officer of the Corporation of the City of London. Mr. Scott was educated at Totteridge, and, on leaving school, entered the service of the

Corporation at once, becoming nominated for a junior clerkship before his age rendered him eligible for such a post. His steady perseverance and strict attention to the minutiæ of the duties devolving upon him won him the favour of his superiors, and he rose steadily in his position until, on his father's death, he was appointed Chief Clerk to the Chamberlain of the City. On the death of his chief, Mr. Anthony Brown, he came forward as a candidate for the vacant office, but was not successful on that occasion. Later, however, on the death of Sir John Key in 1858, he was elected to the post with absolute unanimity, and he remained Chamberlain to the day of his death; his connection with the Corporation thus extending over a period of sixty-five years, and only being interrupted for a short time during Sir John Key's term of office, when for a while he laid aside all City work to devote himself to benevolent and philanthropic work.

His services to the City as Chamberlain during the long period of more than one-third of a century were of the highest order. His management of the finances of the Corporation was most wise and able, and by a judicious rearrangement of the bonds and loans he saved the Corporation large sums annually, thus enabling many well-considered schemes which must otherwise have been dropped for lack of funds to be carried through. Of these schemes, one of the most important, in which he took the most lively interest, was the acquisition of Epping Forest as an open space for the people of London.

He was a most earnest and skilful defender of the Corporation against the numerous attacks which have been made upon it; and his "Statistical Vindication of the City of London," a work upon which he devoted immense care and pains, remains as a monument of his efforts.

Conscientiousness and thoroughness were amongst his chief characteristics, and however small a matter might be he bestowed upon it the same care and accuracy "as if he were drawing a will or framing an indictment." He literally died in harness, for although he was not seen at the Guildhall again after Christmas, 1891, he was engaged upon his official work almost to the last day of his life. He died in 1892 January 17, only three days after the death of the beloved wife, to whom he had been married for nearly fifty years, and who was buried with him at Weybridge Cemetery, 1892 January 19. He was elected a Fellow of this Society 1860 April 13.

Thomas Taylor was born in London on 1814 January 1, and died from chronic bronchitis at Montreux on 1892 March 6. After education by a private tutor, he entered St. Bartholomew's Hospital, where he took the prize for botany. He was in general practice for some years, and also lectured on Chemistry both at St. Thomas's Hospital and at the Middlesex Hospital. Long and serious illness compelled him to abandon his connexion with the latter institution twenty-five years ago, and from that time he

gave little attention to scientific pursuits. He was the first to make known in England Dr. Schoenbein's process for manufacturing gun-cotton, and was the inventor of what is known as parchment paper. He was elected a Fellow in 1845 June, as a member of the Spitalfields Mathematical Society, but never contributed any paper to this Society.

GEORGE TURNBULL was born at Luncarty on 1809 September 2. He received his early education at the Perth Grammar School, and finished his studies at Edinburgh University, after which he came to London to study engineering under Telford, one of whose most trusted assistants he became. Mr. Turnbull was in 1829 elected an Associate of the Institution of Civil Engineers, and until Telford's death in 1834 was his professional representative and confidential clerk, and was connected with a large number of important dock, harbour, and other works. Among these may be mentioned the Bute Docks at Cardiff, the Folkestone and Dover Harbour works, the Shakspeare Tunnel, and the Great Northern Railway. In 1850 he was selected for the responsible position of Chief Engineer of the East Indian Railway, an appointment which he held till 1863, when he retired from active professional life, but he was afterwards employed as arbitrator in various disputes connected with Indian railways. He was in India during the Mutiny, and gave many proofs of his energy and courage in the conduct of engineering works in spite of opposition and difficulty.

Mr. Turnbull became a Member of the Institution of Civil Engineers in 1840, and was elected a Fellow of this Society in December of the same year. He was a Member of the Senate of the University of Calcutta, and a Fellow of various other societies. In 1875 he settled at Rose Hill, Abbott's Langley, on a small estate which he had purchased, where he lived in retirement till his death on 1889 February 29.

W. MATTIEU WILLIAMS was born in London 1820 February 6. His father was Welsh, and his mother Swiss. He was unfortunate in losing his father when quite young, and his mother having married again when he was only eleven years old, he was at that early age obliged to leave school, and thrown entirely on his own resources. He was, however, adopted by a friend of his father, Mr. Z. Watkins, who eventually bequeathed a large fortune to him. Through him he was apprenticed to Mr. Street, optical instrument maker, of London, and for the next nine years he attended, after office hours, the night classes at the Mechanics' Institute, and spent his half-holidays and spare moments in reading. Owing to a great capacity for grasping details and an aptitude for mastering difficulties, he was at the age of nineteen well up in most subjects, but with a decided predilection for the physical sciences. He then, by the help of Mr. Watkins, went through a course of study at the Royal Infirmary at Edinburgh, but he was of too sensitive a disposition to become a good surgeon.

When Mr. Williams came of age he inherited some money from his father, and decided to spend two or three years in travelling, for the purpose of finishing his education. He travelled, always on foot, through France, Switzerland, Italy, Greece, and on to Constantinople. He then returned to Edinburgh, and became acquainted with George Combe, with whose views on education he was in hearty sympathy; and a result of their friendship was the founding of the Williams Secular School, in which experimental science formed an important part of the curriculum.

He went to Birmingham in 1854, and at the foundation of the Birmingham and Midland Institute he was appointed master of the classes then being formed in the industrial department. In 1862 Mr. Williams invented a special retort for distilling paraffin from "cannel" coal, and in 1863 was appointed analytical chemist to Sir John Brown & Co.'s Atlas Iron Works at Sheffield; and it was during this time that he wrote his first book, entitled *The Fuel of the Sun.*

In 1872 Mr. Williams came to Norwood, and gave up his time to writing and lecturing. He gave several lectures at the Royal Institution, and three courses of Cantor Lectures on mathematical instruments, iron and steel, and chemistry of cookery, at the Society of Arts.

Mr. Williams was a large contributor to scientific and educational journals, especially under the headings of "The Chemistry of Cookery," "The Chemistry of Iron and Steel Manufacture," "The Philosophy of Clothing," "Science in Short Chapters," and "Through Norway with a Knapsack." He was elected Fellow of this Society on 1872 June 14, and of the Chemical Society on 1857 May 18. He died on 1892 November 28. S. T. K.

Annibale de Gasparis, foreign Associate of this Society, and formerly Director of the Royal Observatory of Capodimonte, and Professor of Astronomy of the Royal University of Naples, died on 1892 March 21.

Born in Bugnara, in the Province of Aquila, 1819 November 9 (his father being parish doctor of this small village), A. de Gasparis made his first studies at the seminary of Chieti, and there became familiar with the classic writers for whom he ever after manifested a great love and predilection.

In 1838 he came to Naples to study mathematics, of which he had already taught himself the elements. For a time he was a student at the school of engineering, but previous to completing his engineering course he became possessed of a passion for astronomy, and asked and obtained the permission of Capocci to be admitted as a pupil of the Royal Observatory of Capodimonte. He there soon became distinguished for his love of science, and his rare aptitude for observation and diligent calculation. Notwithstanding his exceptional gifts he remained for

eleven years in this humble position, which was much below his capacity.

Towards the end of 1848 he began a review of the smaller stars with the Reichenbach equatoreal, and the help of the Berlin map of the heavens, in order to search for new planets. He was probably encouraged to this work by the recent discoveries of Astræa, Hebe, Iris, Flora, and Metis, which had fallen to the lot of Hencke, Hind and Graham, in a short space of time. On 1849 April 12, he discovered his first planet, Hygeia, and the following year, within an interval of a few months, two others, Parthenope and Egeria. Become famous by these discoveries, he received the gold medal of this Society and the Lalande prize from the Academy of Paris, and was appointed in 1851 Professor of Astronomy of the Royal University of Naples. At the death of Capocci, in 1862, he was appointed director of the Observatory of Capodimonte.

He continued his observations in search of new planets for several years. Besides the three already mentioned, he discovered Irene (four days after Hind), Eunomia, Psyche, Massilia, Themis, Ausonia, and Beatrix. He alternated these astronomical observations with theoretical work, both in astronomy and mathematics, publishing a long series of important memoirs. De Gasparis was of strong physique, and worked hard, interrupting his observations only by brief readings of the classics in which he so much delighted.

About 1885, he began to suffer from creeping paralysis, which gradually became aggravated, and in 1889 the condition of his health was such as to render the fulfilment of his many official duties impossible. He therefore established himself in a country house not far distant from the observatory where he had worked for about forty-five years.

Many honours were bestowed on him; he became a member of the Academy of Italy, as well as of several foreign societies; and he was a senator of the kingdom from 1861.

He was elected a Foreign Associate of this Society 1850 December 13.

Amédée Ernest Barthélemy Mouchez was born in Madrid on 1821 August 24, was educated in Paris and Versailles, and at the age of sixteen entered the Naval School at Brest. He was gazetted midshipman in 1839, lieutenant in 1845, and captain in 1861. The most important event in his naval career was his splendid defence of Havre during the Franco-Prussian War. This side of his life is so little known to those familiar with his career as an astronomer, that a few sentences in relation to it are perhaps not out of place here. "Le capitaine de vaisseau Mouchez fut nommé par le Gouvernement de la Défense nationale, le 18 octobre 1870, commandant des forces de terre et de mer de la place du Havre, ville presque ouverte, que défendaient à peine quelques forts détachés. . . . Il entreprit de

couvrir les approches de la ville par plusieurs lignes de retranchements et par des redoutes, dont il choisit les positions et traça immédiatement les plans, et, grâce à l'énergique impulsion qu'il sut donner aux travaux de défense, les forts, qui constituaient alors les seuls ouvrages de la place, furent au bout de quelques semaines reliés par une ligne fortifiée qu'il arma de pièces de marine . . . L'ennemi avait envahi la Normandie, et la ville de Rouen se sentit menacée; sa municipalité appela aussitôt M. Mouchez et le chargea d'effectuer autour de Rouen des travaux de défense: mais, avant qu'il eût le temps d'exécuter le plan qu'il avait conçu . . ., la ville de Rouen fut occupée par l'armée du général Von Goeben. Les troupes qui couvraient Rouen se retirèrent vers le Havre, . . . et y trouvèrent un abri qui leur permit de se réorganiser. Dès la prise de Rouen l'ennemi tenta une pointe vers le Havre; mais il rebroussa chemin, en apprenant que la ville avait été mise en état de défense; il renouvela cette tentative . . . mais il fut arrêté . . . M. Mouchez perfectionnait les ouvrages de défense . . . et conserva, jusqu'à la signature de la paix, le commandement de la place du Havre et la flotille de la Seine." *

His naval career was also distinguished by some admirable survey work. He spent the five years 1856–1861 in surveying the coasts of Paraguay and Brazil, and a similar period later on the survey of the coast of Algeria; and this work led to his appointment as Member of the Board of Longitudes. In 1874 he organised the expedition to St. Paul to observe the Transit of *Venus*. The climatic conditions of this island of the southern seas made success very problematical, and there were also exceptional dangers in disembarking and otherwise; but the position was so favourable for observation that the risks were undertaken, and, thanks to Mouchez, the enterprise was successful in every way. He gave an account of the expedition before the five Academies in 1875 October, and he was promoted Contre-Amiral and elected Member of the Academy of Sciences.

After the death of Le Verrier, M. Mouchez was appointed (on 1878 June 27) Director of the National Observatory, and he held the post of director till his death in the past year.

From the time of his appointment the staff have displayed the greatest energy, both in carrying on and completing investigations already commenced and in initiating new ones. During his directorate, the arrears in the annual volumes were made up, twenty-one volumes of Annals being published in his fourteen years of office. The re-observation of Lalande's 48,000 stars was immediately pushed forward, and progress has been so rapid that the work of observation is now practically complete, and half of the great catalogue is already printed and distributed, while another quarter is in the press. The catalogue is founded

* *Discours de M. Louis Brindeau, Maire de la Ville du Havre, prononcé aux obsèques de M. Mouchez, le Mardi, 28 Juin* 1892.

on 500,000 observations made at Paris during the last fifty years. Other meridian investigations of a fundamental character have received careful attention from M. Loewy and M. Périgaud. In 1885 the Brothers Henry constructed a photographic object-glass, and commenced a series of experiments in astronomical photography, the success of which is too recent to dwell upon here. M. Loewy was given every assistance in his project for *équatoriaux coudés*, and the work on aberration and refraction on which he proposed to employ one or more of them. Recently a new spectroscopic department, under M. Deslandres, has been established at the observatory. The *Bulletin Astronomique* was founded by M. Mouchez; and a summer observatory was established on the Pic du Midi.

For the last eight years Admiral Mouchez has been of opinion that the Paris Observatory should be transferred to a new site. On 1884 February 4 he presented a memoir to the Academy of Sciences on the necessity for constructing a branch to the observatory. He pointed out that the present site was in a part of the city becoming more and more populous, and proposed to retain there only the museum, an office for calculations, and three or four instruments for instruction; and to construct near Paris an observatory of the first-class, furnished with all the improvements of modern science, the cost of which could be defrayed by selling the ground outside the present observatory. This proposal was negatived by a large majority of the committee appointed to consider it, there being a strong feeling against selling any portion of the present observatory territory. But Admiral Mouchez never gave up the idea. In his subsequent reports he again and again referred to the proposal. He considered that the employment of instruments of great precision or of great optical power were alike impossible at the present observatory owing to the instability of the ground in the one case, and the opacity of the Paris atmosphere in the other. But nothing had yet been done in the direction of moving the observatory at the time of his death.

But it will be as the initiator of the international scheme for charting the heavens that M. Mouchez will be remembered. In presenting the first photograph taken by the Brothers Henry to the French Academy in 1885, Admiral Mouchez remarked on the advantages which a complete photographic survey of the heavens would secure. Dr. Gill had offered to co-operate with the Paris Observatory in such a survey, and it was then estimated that six or eight years would suffice for the work.

In 1887 an international conference was summoned to Paris by Admiral Mouchez, acting under the auspices of the French Academy, and supported by the Government, for consideration of this plan in detail; and a thoroughly representative assembly of nearly sixty astronomers and savants was the result.

The conference resolved generally that recent advances in astronomical photography made it imperative that the astronomers

of our epoch should jointly undertake a photographic survey of the heavens at the present time, taking care to determine the constants which would allow of the positions and magnitudes of stars being determined with the greatest possible precision. Eighteen observatories have provided themselves with instruments essentially of the same pattern, and most of them are now at work on this chart. Details, far more numerous than was at first anticipated, were settled at two other conferences in 1889 and 1891; or by correspondence between members of sub-committees. But it would be difficult to over-estimate the importance of Admiral Mouchez's energy and labour in this preliminary work. His activity in communicating with the sub-committees, his tact and courtesy on occasions of divergence in opinion, his keenness in perception of the wisest course, have smoothed difficulties which, if not perhaps insurmountable, have at times bid fair to delay the undertaking very seriously. With his help a start has been effected which will go far to ensure a successful issue. One of the last things M. Mouchez did as Director, was to establish (in 1892 February) a micrometrical service for measuring the photographs.

Towards the end of his life, Admiral Mouchez suffered from almost total deafness, which was a serious hindrance to some of his work; but the devotion of his friend, Miss Klumpke, did much to obviate the difficulties that might otherwise have arisen. From her many of the particulars in the present brief notice have been gathered. We learn from her that on 1892 June 24, "whether feeling the need of a well-deserved rest, or with some mysterious prevision of his approaching end, the Director convoked MM. Davanne, Loewy, Wolf, Paul and Prosper Henry, and read out the programme he had prepared on various subjects under discussion, requesting them to share with him the responsibility of their solution. Having thus made, as it were, his scientific will, having confided to their hands the great work he had begun, he returned to his beautiful country-seat at Wissons. On arriving there he declined all nourishment and laid down to rest, and before another dawn he had passed peacefully away, surrounded by his loving and devoted family." He died on 1892 June 29.

Lewis Morris Rutherfurd was born at Morrisania, N.Y., on 1816 November 25. He graduated at Williams College, where he gave evidence of considerable scientific ability and zeal. He was called to the Bar in 1837, but having married a lady of some fortune early in his career, in 1849 he abandoned the law to devote all his energies to science. He first came to Europe, and remained there for some time travelling and studying. On his return to New York he erected a small observatory (transit, clock, and equatoreal) at the back of his house, and his observations were from the first of considerable importance. In 1863 he published in *Silliman's Journal* a paper on the spectra of stars, Moon, and planets, which is the first published attempt at classi-

fication of star spectra.* He there suggested a rough classification of the spectra into three groups: "First, those having many lines and resembling the Sun, all reddish or golden stars; secondly, white stars, like *Sirius*; the third group comprising *Spica*, *Rigel*, etc., also white stars, but showing no lines."

In the course of his observations with the spectroscope Mr. Rutherfurd discovered its use for making a photographic object-glass, and in 1864 he succeeded in devising and constructing an 11¼-inch glass (*Am. J. of Sc.*, 1865 May) of fifteen feet focal length, corrected for the photographic rays, with which many very successful photographs were taken of the Sun, Moon, and stars. In 1868 he finished a 13-inch—an ordinary achromatic, to which a third flint lens could be attached in a few minutes when it was desired to use the telescope photographically. The beautiful photographs taken with these instruments were in 1890 presented to the Columbia College Observatory, together with twenty folio volumes, of about 200 pages each, containing the measures of many of the plates. A complete catalogue of them, given by Mr. J. K. Rees (*Annals of the N.Y. Acad. of Sc.* vol. vi. 1891 June) shows 175 solar, 435 lunar, and 664 stellar plates, and 174 plates of the solar spectrum. The measures were made by Rutherfurd with micrometers of his own devising. In the first he used a long screw, and that the measures even with this instrument were excellent was shown by Dr. B. A. Gould in two papers read to the Nat. Acad. of Sc. in 1866 and 1870. The merest summary of these papers was published at the time, and the details were not printed till many years after. In 1870 Dr. Gould was, as is well known, called to Cordoba for (as he then thought) three years, and he left the publication of the star measures till his return. He took with him the 11¼-inch telescope, but the object-glass was unfortunately cracked in transit. He put together the pieces and made some photographs of the southern stars, but afterwards obtained another lens. It was fifteen years before Dr. Gould returned to the States, and could arrange for the printing of the two memoirs by the National Academy. The real investigator, Mr. Rutherfurd, meanwhile made no effort towards this consummation, partly

* It should not be forgotten that Fraunhofer, using a prism before the object-glass, observed the spectra of *Capella*, *Betelgeux*, *Procyon*, and *Pollux*, in which he recognised the solar D; and also of *Castor* and *Sirius*, which were different. These results in 1823 were really the first to show that the spectra of stars differ from each other and from that of the Sun. Immediately after Kirchhoff's discovery of the true meaning of the Fraunhofer lines, Donati in Florence, Rutherfurd in the United States, and Huggins and Miller in England, all worked independently (and unknown to each other) at the spectra of stars and planets. Donati published a paper on stellar spectra in the *Annali del Museo Fiorentino* for 1862, but his method and results were very imperfect. When Dr. Huggins and Dr. Miller arrived at the Royal Society, on 1863 February 26, to read their first paper (dated 1863 February 17), they were surprised to find the copy of *Silliman's Journal* containing Rutherfurd's paper mentioned in the text.

from ill-health and partly from that dislike to the act of publication only too prevalent among eminent scientific men. But the long-screw micrometer was not satisfactory, and Rutherfurd was led to devise one with a glass scale, the principle of which is now too well known to need description. The measures made with the glass-scale micrometer are at last being reduced and published by the Columbia College, and Mr. H. Jacoby has shown in two memoirs (on the *Pleiades* and the *β Cygni* group) how excellent are photographs and measures alike. Thus the chief part of Rutherfurd's astronomical work is only now being made generally accessible.

During 1870 Mr. Rutherfurd constructed a ruling-engine, described and figured in *Appleton's Cyclopædia*. With this beautiful apparatus he produced superb interference gratings on glass and on speculum metal. Some of the ruled plates had 17,000 lines to the inch; they were superior to all others down to the time when Professor Rowland perfected his machine.

Among his other work may be specially mentioned his photograph of the solar spectrum by using a bisulphide of carbon prism (1864); his method of adjusting a battery of prisms to minimum deviation (1865); his demonstration of the stability of a collodion film (1872); and his project for using a glass divided circle instead of one of metal (1876).

Mr. Rutherfurd was one of the founders of the National Academy of Sciences. He took a most important part in the International Meridian Conference at Washington in 1885. For more than twenty years he was a member of the Board of Trustees of Columbia College, and received the degree of LL.D. at the Centenary in 1887. Weak health prevented his accepting many scientific engagements in which he was invited to take a prominent position. For twenty years past he was compelled to spend his winters either in Florida or in the south of France. He contracted a severe cold on his journey south in 1891, and never fully recovered from its effects. He died peacefully, and without apparent pain, on 1892 May 30, in his seventy-sixth year.

He was elected an Associate of this Society on 1872 November 8.

Proceedings of Observatories.

The following reports of the proceedings of observatories during the past year have been received from the directors of the several observatories, who are alone responsible for the same:—

Royal Observatory, Greenwich.

The past year has been an exceptionally heavy one in various ways, and has somewhat severely taxed the energies of the staff. Two new assistants were appointed in February to fill vacancies which had existed for some time; and the observatory was for some months without the services of a clerk. Important changes in the buildings have occupied much of the attention of the Astronomer Royal; and, finally, two important longitude operations have required nearly the whole time of Mr. Hollis during three quarters of the year, and a considerable portion of that of the Chief Assistant.

It might therefore be expected that the regular work would necessarily suffer to some extent; but it is reassuring to find that the arrears (chiefly in the printing) are not serious, and will probably be effaced early in 1893. The total number of transits observed in the year 1892 is 6,212, and of zenith-distances 5,607, which numbers compare favourably with those for any previous year. The total number of stars observed in 1892 was 1,722.

The reductions for the Five-year Catalogue of Fundamental Stars from observations in the years 1887–1891 are completed, and the Catalogue will be published as an appendix to the volume of Greenwich Observations for 1891. Meanwhile the resulting star-places have been communicated to the Superintendent of the *Nautical Almanac* and used by him in the *Nautical Almanac* for 1896 (just published).

The N.P.D.'s of the Ten-year Catalogue have been analysed by comparing the results for the separate years with the mean. The comparison suggested periodic fluctuations of latitude of the kind found by Mr. Chandler in his recent investigations; and on a more direct reduction of the Greenwich observations from 1851 to the present time being undertaken by Mr. Thackeray. Mr. Chandler's doubly periodic variation of the latitude (in about 365 and 427 days respectively) was very satisfactorily confirmed. The results have been given in two papers communicated to the Society by Mr. Thackeray (*Monthly Notices*, liii. pp. 2, 120).

The mean error in R.A. of Hansen's Lunar Tables, with Newcomb's corrections, as deduced from 111 observations with the Transit-Circle in 1892 is + 0^{s}·069, agreeing well with the results for previous years since 1883.

Recent observations of horizontal flexure by means of the collimators show that the coefficient is still very small. The apparent correction to nadir observations deduced from reflection observations of stars is − 0″·25, a rather large quantity. No correction for flexure, or for the above nadir discordance, has been applied to the observations apart from the R − D correction.

Observations with the altazimuth were intermitted during the months May to October, owing to the great pressure of other work. In the remaining months the Moon was observed regularly during the first and last quarters. The proposition to replace this instrument by a Universal Transit-Circle, as described by the Astronomer Royal (*Monthly Notices*, lii. p. 480), has been sanctioned by the Admiralty.

Five comets have been observed during 1892 with the Sheepshanks Equatoreal, viz.: Comet (*a*) 1892 (Swift) on fourteen nights; (*c*) 1892 (Winnecke) on one night; (*d*) 1892 (Brooks) on nine nights; (*f*) 1892 (Holmes) on nine nights, and (*g*) 1892 (Brooks) on three nights.

Twenty-five occultations of stars (including seven disappearances and three reappearances of stars during the lunar eclipse of 1892 May 23); the occultation of *Uranus* by the Moon on July 3; the occultation of 73 *Piscium* by *Jupiter* on May 23; and 49 phenomena of *Jupiter's* satellites, have been observed with the Equatoreals, by one or more observers.

With the Astro-photographic Equatoreal 489 plates, involving 1,222 exposures, have been taken during the past year. The total time of exposure, exclusive of trails for orientation, was 127^{h} 8^{m}. Of the plates, 88 were Chart and 220 Catalogue plates, 67 were for instrumental adjustment, 75 of *Nova Aurigæ*, 13 of the *Pleiades*, 16 of various regions, and 10 were attempts at Chart plates cut short by clouds. The plates of *Nova Aurigæ* have been measured for determination of the magnitude of this star at different epochs, and the results have been communicated to the Society. Four of the miscellaneous plates were exposed on *Jupiter*, a concave enlarging lens (specially made by Dallmeyer) being used to magnify the image about 15 times. The photograph micrometer used for the measurement of Transit of *Venus* (1874) photographs has been modified for use with the stellar plates. The measures can be made quite independently of the *réseau*, which will be an advantage if this auxiliary has ultimately to be dispensed with, owing to the decomposition of the film, which it seems difficult to prevent. As regards the selection of guiding stars for the plates of the chart:—Since the date of the last report the remainder of the catalogue for zone +60° to +65° (Rome) has been sent to Father Denza; the

second 12 hours of R.A. of the zone $+25°$ to $+29°$ (Oxford) has been sent to Professor Pritchard; the catalogue for $12^h - 18^h$ R.A. for the zone $-3°$ to $-5°$ (San Fernando) has been completed, and the approximate star-places for R.A. $0^h - 12^h$ and R.A. $18^h - 24^h$ have been communicated to Dr. Becker, of Strassburg, who is determining accurate places by meridian observation.

The 12¾-inch Merz refractor, dismounted in 1891 November to make room for the new 28-inch refractor, was mounted in place of the Lassell reflector on 1892 April 13, the Thompson photo-heliograph being attached to the tube. In its present position, however, it cannot be effectively used owing to the interference of the new building of the proposed Physical Observatory, on the central tower of which it will, as is hoped, soon be mounted, together with the Lassell dome. The old south-east dome was dismounted in November, and operations for the erection of the new 36-foot dome which is to cover the 28-inch refractor, were commenced by Messrs. T. Cooke & Sons in the middle of December. No spectroscopic observations have been made during the year.

Photographs of the Sun have been taken with the Dallmeyer 4-inch photo-heliograph on 210 days, and of these 518 have been selected for preservation, including 29 photographs with a double image of the Sun, taken to determine the position of the wires with reference to the parallel of declination.

For the first three months of the year the Dallmeyer photo-heliograph was mounted on the first floor of the new museum, from which it was removed on April 6 to its old position in the wooden dome south of the Photographic offices. Here it remained during the summer months until the Sun was no longer sufficiently high to be observed over the roof of the new museum building, and on September 9 the photo-heliograph was once again transferred to the new museum.

Photographs of the Sun have also been taken with the Thompson photo-heliograph on 35 days during the year. A new enlarging lens has lately been supplied for this instrument by Messrs. Ross & Co., with very satisfactory results as regards flatness of field and freedom from distortion. Photographs have also been received from India and Mauritius up to December 6, leaving seven days in the year ending on that day for which no photograph is yet available for measurement.

The increase in the solar activity which was so marked in 1891 has continued during 1892. The Sun has not been free from spots on a single day; as many as ten or eleven distinct groups have often been seen on the disc at the same time. Several of the groups observed have been of very great size and complexity, and one (that of Feb. 5–18) was by far the largest ever photographed at the observatory. It is premature yet to decide whether the actual maximum has been attained, but the great increase in the number of the spots appears to point to its being near at hand.

The operations for determining the longitude of Montreal were successfully concluded in September. In the spring (April and May) two series of observations were completed, the observers at Greenwich and Waterville (Ireland), and at Montreal and Canso (Nova Scotia), being interchanged between the two series, but no exchange of observers being made across the Atlantic. For the autumn operations Professor McLeod, of Montreal, came to England, and Mr. Turner crossed to Canada, and interchanges of observers were made as in the spring, between the pairs of stations separated by the cable.

The following table shows the number of nights of observation at the several stations in the four parts.

Part.	Greenwich.		Waterville.		Canso.		Montreal.	
	Full Nights.	Half Nights.	Full Nights.	Half Nights.	Full Nights.	Half Nights.	Full Nights.	Half Nights.
I.	5	2	3	2	6	...	3	1
II.	6	...	5	2	3	...	2	3
III.	8	4	4	3	4	3	6	3
IV.	7	3	2	4	10	1	5	1

Signals were exchanged on each night between Greenwich and Waterville, between Waterville and Canso (the cable termini), and between Canso and Montreal. A few experimental signals were exchanged between Greenwich and Montreal, being automatically registered and repeated at the intermediate stations, but the results were not so satisfactory as those of the signalling independently in sections. Discussion shows that the transatlantic signals are practically as good as those over short land lines, excepting that the time of transmission is greater, and hence there is a larger chance of error from the necessary assumption of equality in the time of transmission in opposite directions.

The reductions are so far advanced as to show that the determinations in the spring and autumn for Waterville are accordant *inter se*, and agree with the geodetic determination within 2″, *i.e.* well within the limits of error due to local attraction. The results for the transatlantic stations are also so far satisfactory, judged by the standard of accordance *inter se*.

The longitude of Paris was also redetermined in June and July (in the interval between the two series for Montreal), in concert with the officers of the French Service Géographique. Observations were made at Greenwich on seventeen, and at Paris on twenty nights. The reductions are not yet sufficiently advanced to pronounce definitely on the subject of the discordance found in 1888.

While in England, Commandant Defforges took the opportunity of swinging his pendulums at this observatory, and at Leith Fort, Edinburgh, where Captain Kater had made observations. Thus the French pendulum observations will be connected with the English and Indian.

October 4. By the end of the year the whole of the main building with its east and west towers was well in progress. The walls are built of grey sandstone, from Hailes Quarry, to the west of Edinburgh, but are faced with a reddish freestone procured from Doddington Hill, in Northumberland.

Including the cost of drainage, water-pipes, pumping-chamber, and fencing, the expenditure at the close of the year was a little over 4,000*l*. Greater progress would have been made but for the severe frosts, which not only stopped all building, but also cut off the supplies of stone from the quarries.

At Calton Hill, Mr. Heath has carried on the time service, the meteorological reductions, and the preparation of weather-returns for the Registrar-General for Scotland, as in previous years. The revision of the Edinburgh star places has also been carried a stage further. A redetermination of the latitude with the mural circle is also in progress.

In July, Lieutenant Gratzl, of the Austrian Navy, observed the times of vibration of a pair of invariable pendulums at Calton Hill, preparatory to a visit to Jan Mayen, where the observations were to be repeated.

Fifteen astronomical circulars have been issued in the course of the year. The thanks of observers are due to Messrs. Berberich, Schorr, H. Oppenheim, and Archenhold, for their important contributions to these circulars. No. 22 is specially interesting, as containing the earliest notice of the outbreak of *Nova Aurigæ*. It is almost superfluous to add that this wonderful object was first seen by Dr. T. D. Anderson, of this city, who also independently picked up Comet Holmes two nights after its discovery in London. The *Nova* was observed on every favourable occasion until its disappearance, not only at Calton Hill, but also at Dunecht, by Dr. L. Becker, who went there the moment the star's extraordinary character was perceived. The results of these observations are published in the *Transactions of the Royal Society of Edinburgh* (vol. xxxvii., p. 51). On its re-appearance in the autumn, the star was again studied with the Dunecht refractor by Professor Copeland, with the valuable aid of Mr. J. G. Lohse, who was staying there for a short time. A later attempt made by Dr. Becker to secure a photograph of the spectrum was unsuccessful, owing, probably, to a want of sufficient clear sky for a lengthy exposure, for the same apparatus yielded a spectrum of *Jupiter*, full of minute detail.

In November and December Dr. Becker completely dismounted and packed the transit circle, together with the piers and collimators. The granite-work of these piers and their foundations is very beautiful and solid, and will be used again at Blackford Hill. The task of separating these massive cut stones was much lightened by the aid of the experienced and skilled mason, Mr. John Smith, who had erected them twenty years ago, and who, it is hoped, will rebuild them in their new quarters.

In continuation of his published work on the Low Sun Spectrum, Dr. Becker has reduced the late M. Thollon's Solar Spectrum to Rowland's wave-lengths and compared them with his own results. He has also revised the papers on *Nebulæ* and on *The Latitude of Dunecht*, mentioned in last year's report.

Shortly after the new year, Dr. Becker was appointed successor to the late Dr. Grant in the Chair of Astronomy in Glasgow.

Just before daybreak on the morning of March 8, fire broke out in the official residence of the Astronomer Royal for Scotland. When it was first perceived, one corner of the house was already burning fiercely, from foundation to roof—five stories in all. Happily the inmates escaped unharmed. Notwithstanding the promptest exertions on the part of the police and the fire-brigade, the corner where the fire broke out, the whole of the roof, and the top flat were destroyed by fire, while much injury was inevitably done to the rest of the house by water. Fortunately the library was not materially damaged, though for months the books required continual turning over to prevent the inroads of mildew. The most valuable works entirely escaped injury, owing to their position in well-glazed cases in another part of the house. Practically ten months were required before the house and library were again in order.

By an oversight, wrong figures were given for the latitude of the new observatory on p. 190 of *Monthly Notices*, vol. l. The approximate latitude is 55° 55′ 28″·0.

Royal Observatory, Cape of Good Hope.

The inadequacy of the computing force for the past ten years has led to large and growing arrears of reduction which no effort on the part of the existing staff could overtake. The Lords Commissioners of the Admiralty having granted an addition to the computing staff, it appeared to H.M. Astronomer that the time had arrived to make a supreme effort to overtake these arrears. Accordingly, all meridian-observing not absolutely required has been suspended during the year; the assistants have thus been enabled to give much additional time to the work of reduction, and, as will be afterwards evident, a great amount of the arrears has been overtaken, although not so much as would have been but for the serious illness of two of the assistants.

The series of meridian observations of the Sun, *Mercury*, and *Venus*, with the brighter clock-stars, was continued until September 21, when it was interrupted by necessary repairs to the floor of the Transit Room and Central Hall. On removing the old flooring-boards of the Transit Room, it was found that the framework of beams supporting the floor, and even the strong wooden pillars which supported the roof, rested on the foundation of the transit circle piers. This explained the great difficulty which

had often been experienced in getting sufficiently steady images in reflex and nadir observations. Complete reconstruction of the framework of the floor and support of the roof became necessary—a work that was at once undertaken by, and is still in the hands of, the Director of Works Department.

The observations secured with the transit circle have been :—

	R.A.	N.P.D.
Observations of the Sun (both limbs)	77	74
„ Mercury	39	37
„ Venus	48	49
„ Azimuth stars	82	...
„ other stars	789	509
	1035	669

No. of determinations of Collimation	43
„ „ Level	247
„ „ Run	2°0
„ „ Flexure	35
„ „ Nadir	2So

Besides these, meridian observations of the Declination of Mars and the comparison stars of the Washington Programme were obtained on forty-four nights.

The weather, during the year, has been the most unfavourable for observing ever known at the Cape. The rainfall at the observatory was 40·9 inches, as compared with the average (for the past fifty-one years), 25·8 inches; but this proportion in no way expresses the much greater relative proportion of cloudy weather. Icebergs have been reported within sixty miles of Cape Point, and an unusual number of whales have entered False Bay and Table Bay. These facts probably point to an abnormal northward set of Antarctic currents ; and hence, perhaps, the unusually damp and cloudy weather which has been experienced.

The following occultations of stars by the Moon were observed :—

Disappearances at dark limb	9
Reappearances „	4
	13

With the heliometer, observations for the parallax of six stars were made on twenty-four nights ; forty observations of position-angle and distance of stars occulted by the Moon on 1891 November 15 were also made. In accordance with Dr. Lohse's request, forty-five observations of the position-angle of the polar-spot on *Mars* were made near the time of opposition.

The zenith telescope has been employed by Dr. Gill in an

investigation on the Constant of Aberration and Change of Latitude; 574 observations were secured by him.

Comet *a* 1892 (Swift) was observed on fourteen nights.

The damp and cloudy weather has been especially unfavourable for photographic work. Many preliminary experiments had to be made before all practical details connected with the plans of the Astrophotographic Congress could be satisfactorily worked out. Regular work was begun on July 26, and so unfavourable has been the weather that only "catalogue" plates have as yet been attempted. Of these have been obtained :—

Successful plates	307
Rejected	58
Standard areas	35
Total	400 = 1200 exposures.

The following miscellaneous photographs were taken, chiefly previous to July 26, when regular astrophotographic charting commenced :—

	Plates.	Exposures.
Adjustments, screen experiments, &c. ...	50	211
Stars occulted by Moon 1891 November 15	26	52
η Argûs	13	13 (5^s to $12\frac{1}{4}^h$)
α Centauri (as a double star)	5	136
ω Centauri (cluster)	3	3 (14^m, 1^h 53^m, 3^h)
κ Crucis (cluster)	1	1 (35^m)
Lunar eclipse 1892 May 11	10	10
Plates for stellar parallax	16	85
Comparison of areas in various galactic latitudes	12	15
Total	136	526

Much labour has been given to experimental work in measuring plates and reducing the measures, determining *réseau* errors, &c., but it has become necessary to suspend all such work for the present, until other arrears are overtaken.

The state of the reductions of the meridian observations is as follows: The Cape General Catalogue for 1885, the Annual Meridian Volumes for 1885, 1886, and 1887 are ready for press, and the volumes for 1888 and 1889 are being copied for press. The observations made in 1890 are completely reduced and examined to "apparent place," and the "mean places" are computed and partly examined. For 1891 the computation and examination are complete to "apparent place"; the duplicate copy of the corrections to reduce to mean place has to be computed and the corrections applied. For 1892 the R.A. is completely reduced and examined to April 17, and the N.P.D. to the end of the year.

With respect to the extra-meridian observations, the chief labour of reduction has been connected with the discussion of the observations made in 1889 and 1890 in carrying out the proposals of H.M. Astronomer for observing the minor planets *Victoria* and *Sappho*. The preliminary part of this work (the discussion of the heliometer triangulation of the comparison stars) was completed early in the year, and a short outline of the results of the work is published in the *Ast. Nach.*, No. 3107.

The discussion of the observations of *Victoria* is now nearly complete, and will be quite so (so far as the Solar Parallax is concerned) before this report is in the hands of the Society.

The comparison of the observations with the ephemeris has apparently demonstrated with great weight that Le Verrier's value of the constant of the Lunar Equation must be diminished about $\frac{1}{60}$ part, and that, with the resulting value of the Solar Parallax, the accepted value of the Moon's mass must be diminished by more than one per cent. The amount of the correction to the Lunar Equation comes out nearly the same from each of the three lunations over which the observations extend, and from the Declinations as well as the Right Ascensions; although, of course, with much lower weight from the Declinations than the Right Ascensions.* These results depend upon heliometer observations made at the Cape, Yale, Leipzig, Göttingen, and Bamberg, in 1889 (June 10 to August 24, both days inclusive). During the whole of this period there were secured over 800 observations (involving 4 pointings each) in each hemisphere, and there are only six nights during the whole period on which no observations were secured at one or more of the observatories. The combined efforts of many astronomers, and the generous co-operation of the directors of many observatories have made it possible to determine places of the comparison stars so exactly that the absolute path of a planet has (for the first time in the history of astronomy) been followed over nearly three complete lunations, with greater precision at every point than has the annual parallactic ellipse of any fixed star whose parallax has as yet been determined.

For the *Sappho* observations the equations of condition are formed, and the whole work will be ready for press within a few months.

A small volume of observations of comets 1880–1889 (except the great comet of 1882, already published), with more accurate places of the comparison stars and final revision of all the observations, is ready for press.

Tables for facilitating the computation of "star-corrections" to mean place have been completed by Mr. Finlay on the plan which

* The definitive determination of the Lunar Equation requires a rediscussion of the work, based on new heliocentric ephemerides of the Earth and *Victoria*; and in the computation of the former the lunar perturbations, instead of being taken from Le Verrier's tables, should be rigorously computed from the co-ordinates of the Moon.

he proposed in *Monthly Notices*, vol. l., p. 497, from declination 0° to 75° and, on a modified plan, from 70° to 88°. They are being employed in computing the check corrections for 1891, and are found to save much time. If, after further trial, this experience is confirmed, it is proposed to print the tables in the publications of the observatory.

So severe has been the pressure on the still inadequate computing force, that it has been impossible to attempt the reduction of the heliometer stellar parallax observations, the observations of the mutual distances and position-angles of *Jupiter's* satellites, the zenith telescope observations, the measures of *réseaux*, a large collection of measures of photographic plates, the reduction of occultations, as well as a valuable series of meridian observations of the Sun, Moon, and fundamental stars, made under Sir Thomas Maclear's directorate in the years 1861–1870, which should certainly be published.

Professor Kapteyn reported, under date 1892 June 12, that the last plate of the Southern Photographic *Durchmusterung* had been measured; and he now informs me that the first sheets of the Catalogue will be ready for press in February. An apparatus, designed by H.M. Astronomer, for engraving the maps of the *Durchmusterung* has been received from Messrs. Troughton and Simms.

The field work of the geodetic survey was completed on September 30, and Major Morris and his party are now engaged at the observatory in completing the reductions. The whole of the observed angles are completely corrected for run and level, and the definitive lengths of the three base-lines (Natal, Port Elizabeth, and Kimberley) have been deduced. A preliminary computation of the whole triangulation has been made, and a mean fundamental origin in latitude, longitude, and azimuth determined. The small corrections to the angles have also been computed, which are necessary to equalise the length of any of the four base-lines * (computed from any other base through the triangulation in any direction), with its measured length. The final portion of the computations is now in progress, viz., the computation of the small final corrections so necessary to complete the harmony of the gridiron chains of triangles at their points of junction.

Major Morris rejoins his corps on completion of this work, after ten years' service in South Africa, rendered conspicuous by the energy, tact, and ability which he has devoted to the work of the survey, and the success with which he has overcome the many difficulties which beset such a work in a country where the scarcity of water and difficulties of transport and supply are so great.

* The fourth base-line is that measured by Maclear (in Zwartland), the observed and computed lengths of which have been found to agree very harmoniously with the modern work.

Cambridge Observatory.

During the year the work has progressed on the same lines as in recent years.

The reductions of the observations are nearly completed up to the end of this year, and the arduous task of reduction to epoch for the zone stars, and arrangement of each individual result in order of right ascension, has been accomplished for nearly the first twenty hours, embracing about 33,000 places of small stars. The smaller catalogue, which will give the place of each star from the mean of all the observations, has made some progress, but cannot be taken up vigorously until the larger be completed.

The work with the transit circle has been chiefly directed to the observation of stars which had been overlooked in the preparation of the observing catalogues, or had been imperfectly observed, and to the observation of stars which had been compared with comets.

Several requests for accurate places of stars contained in the zone assigned to this observatory have been promptly met.

The Northumberland Equatoreal has been got into much better working order. The woodwork of the roof was much decayed, and has been replaced by sound material; so that the dome now revolves freely; the driving clock was put into the hands of a competent workman, and now carries the instrument round with comparative regularity. Under these improved conditions the telescope has been used much more frequently than during previous years. Preparation was made for observing the eclipse of the Moon on May 11, but clouds prevented observation.

The weather was very unfavourable in November—we only got five nights with Holmes' Comet. In these we obtained thirty-three comparisons with adjacent stars, using the square-bar micrometer. The places of some of the stars have been observed with the transit circle.

The Newall Telescope, Cambridge Observatory.

The Newall telescope (25 inches aperture) has been used for observation on 122 nights in the course of the year 1892.

Some difficulty was experienced in the final adjustment of the instrument, and this was traced to the obliquity of the line of collimation to the declination axis. Alterations have been made, which have so far reduced the error that further trouble has not arisen.

The new clockwork and gearing, constructed by Sir Howard Grubb, has just reached Cambridge (1893 January 2); and only the old inefficient clockwork has been available hitherto, so that observations involving the use of clockwork have been made at great disadvantage.

Under these circumstances some time has been devoted to the observation of the following planets :—*Saturn*, *Jupiter*, *Mars*, *Venus*, *Uranus*, *Neptune*, and drawings have been made on several occasions.

Attempts have been made several times to see Barnard's satellite of *Jupiter*. Twice a faint object was suspected near the place indicated in Marth's ephemeris, but never with such certainty as to warrant a statement that the satellite had been seen.

[Note on February 10. The satellite has since been seen with certainty twice.]

A drawing (date, April 29) of Comet *a* 1892 (Swift) shows rifts in the tail, such as the photographs of Russell, Barnard, and Wolf record. It may be remarked that the drawing was made some time before receipt of the photographic results.

The work of the year has necessarily been mainly of a preparatory nature, which, with the exception of two branches need not be specified.

Some preliminary visual photometer work has been attempted. The variation in brightness of *Nova Aurigæ* has been followed, both in the earlier and in the later appearance. A wedge photometer, having a wedge interval of about 1 inch per magnitude, is being calibrated, with a view to its application to the photometry of faint stars; it is found that the wedge is incapable of extinguishing a 10th magnitude star at its thickest end and a 15th magnitude star at its thinnest end, when the full aperture of the objective is used. Some of the regions chosen by the American committee on standards of stellar magnitude have been investigated, and this work is being continued.

Through the kindness of Mr. Lockyer two objective prisms of 10½-inch aperture and 7½ degrees angle were put at our disposal by the Science and Art Department, South Kensington. These were mounted with a rigid framework in front of the object glass, and between August 15 and November 19, on which day the driving-screw of the Equatoreal was dismounted and sent to Dublin, eighty photographs of bright star spectra were taken, and though perhaps only sixteen of these are of use for measurement, the preliminary difficulties are in the main surmounted. With a single prism the photographed spectra are 2 inches long between F and H; and the spectrum of *Vega* was photographed with an exposure of nine minutes, and shows the hydrogen lines up to ζ (Huggins' notation), though the more refrangible lines are diffuse; the length of the spectrum from F to ζ is a little greater than 3 inches.

Dunsink Observatory.

There have been considerable changes at this observatory during the year which has just elapsed. On February 20 Sir Robert Ball, then Royal Astronomer of Ireland, was appointed to succeed the late Professor Adams as Lowndean Professor of Astronomy

and Geometry in the University of Cambridge. The vacancy thus caused in the directorship of the Dunsink Observatory was not filled up till October 22, when Dr. Arthur A. Rambaut, who had been assistant to Sir Robert Ball for the last ten years, was elected to the post. Dr. Rambaut, shortly after his appointment, nominated as his assistant Mr. Arthur E. Lyster, of Trinity College, Dublin.

The 15-inch Roberts reflector has been employed during the year for the purpose of obtaining stellar photographs, principally with a view to the determination of parallax. During the year 201 photographs have been obtained, representing 443 exposures, varying from 30^m to a few seconds in length. Exposures exceeding 30^m are never attempted at this observatory on account of the irregularities of the driving-clock, which entail an uninterrupted watch exceedingly difficult to sustain. The width of the shutter-opening, too, so little exceeds that of the main telescope and pilot together that, except near the pole, it is necessary to interrupt the exposure every fifteen or twenty minutes in order to turn round the dome.

Amongst the plates obtained are included fourteen photographs of the new star in *Auriga*, taken shortly after its first appearance in February, March, and April, and nine photographs in August, September, and October, on the renewal of the star's brightness taking place. As these observations are separated by an interval of six months, and as the star was during each period near one of the apses of its parallactic ellipse, it is hoped that the photographs may serve for a determination of the star's distance. The examination and measurement of the plates have, however, not yet been completed, being delayed by the interruptions consequent on the changes in the observatory staff.

In July and August fifteen photographs of the planet *Mars* were taken, with the view of determining its position with regard to the stars in its neighbourhood. In these photographs a small occulting shutter was used, similar to the shutter described on p. 197 of Dr. Joly's paper, "On Shutters for use in Stellar Photography," in vol. vii. pt. 3 of the *Scientific Proceedings of the Royal Dublin Society*, of which a short notice was published in *Nature* 1891 December 17, p. 167.

With this shutter it is possible to occult any selected object for any desired fraction of the exposure given to the rest of the plate. The shutter is manipulated by means of an electric key from the eye-end of the telescope. In this case the plate was exposed for 10^m, while the planet's image was allowed to fall on the plate for only 2^s at the middle of the exposure. This exposure gave on the Paget prize plates a well-defined disc to the planet, while on most of the plates there are several comparison stars to be found in proximity to it, by which its position can be accurately determined.

During the year 2,576 micrometer measures of stellar photo-

graphs have been made with the Troughton & Simms microscope, presented to the observatory by the Royal Irish Academy. A large proportion of these measures refer to the photographic survey of the star-cluster χ *Persei*, which was in progress at the date of last report. The results of this preliminary investigation are published in the *Transactions of the Royal Irish Academy*, vol. xxx. pt. iv. This memoir contains, in addition to the measures themselves, an exposition of the method of measurement, a chart of 223 of the principal stars laid down from the measures, and the formulæ of reduction which we were led to adopt.

A further examination of the correction for refraction to measures of stellar photographs by Professor Rambaut will be found in the *Astronomische Nachrichten*, No. 3125. The formulæ there given have been found to be very convenient, especially if, as has been done for this observatory, the values of the quantities m, n, μ, ν are tabulated for every minute of hour angle.

During the lunar eclipse of May 11 thirteen photographs of the Moon were taken, showing the progress of the Earth's shadow across the disc. These photographs were exhibited at a meeting of the Royal Dublin Society, and seem to show that for short exposures (2^s) the outline of the shadow was to a great extent modified by the nature of the surface upon which it fell, and was very difficult to define, but that with exposures of a minute or so a well-defined circular outline was obtained, although most of the detail on the surface was thereby sacrificed.

There has been no systematic work done with the meridian circle during the year. The place of Holmes' comet was determined with it on November 19, but with the exception of this and a few other observations, the work of this instrument has consisted of time determinations for the service to Dublin and the use of the observatory. There have been in all 366 observations made with this instrument.

The "South" refractor has been in occasional use for observations of *Saturn*, *Jupiter*, and *Mars* when in opposition, for observations of Holmes' Comet, and on the first Saturday of the month it has been put at the disposal of visitors to the observatory.

For the ensuing year Professor Rambaut intends to employ the Roberts reflector for stellar parallax work, as he has done for some time past, while the meridian-circle in connection with the chronograph will be devoted to the investigation of the proper motion of stars.

An account of an investigation of the absorption of heat in the Sun's atmosphere, in which Professor Rambaut has been associated with Mr. W. E. Wilson, will be found in the report of the work of Mr. Wilson's observatory during the past year.

Glasgow Observatory.

The operations at the Glasgow Observatory for the past year have consisted mainly in the completion of the "Second Glasgow Catalogue of 2,156 Stars for the Epoch 1890." This catalogue, which is now distributed to the leading astronomers and institutions all over the world, was undertaken with the object of ascertaining the cause of discrepancies which existed between the places of certain stars as given in the first Glasgow Catalogue and the corresponding places of Weisse's Bessel Catalogue. To this list a considerable number of new W. B. stars were added. A comparison was then instituted between the results of these observations and the corresponding places reduced from Baily's Lalande and Weisse's Bessel Catalogues, and when appearances seemed to indicate proper motion other authorities were looked up to confirm it. The results of these researches are given in the list of 192 stars of decided proper motion in the Introduction to the new catalogue. The meteorological work of the observatory has also been carried on as in former years.

Liverpool Observatory, Bidston, Birkenhead.

Since the appointment of the new director a very thorough examination of the transit instrument has been made, and notwithstanding its fifty years of constant service, the instrument is still adequate for the purposes in which it is engaged. In connection with a chronograph, constructed on plans supplied by the late Professor Bond, of Cambridge (Mass.), it is proposed to carry on the investigation of the parallax of some binary systems after the plan successfully adopted by Professor J. C. Kapteyn.

The Equatoreal (8 inches) has been, and in the future will continue to be, employed in the systematic observation of comets.

The self-registering meteorological instruments have continued in uninterrupted operation throughout the year, and no change is proposed in their arrangement. The discussion of the meteorological records, accumulated during the last twenty-five years, is contemplated. The digest of meteorological observations made under the superintendence of the late Mr. J. Hartnup in 1889–1891 is now in the press, and the results will shortly be sent to those who are sufficiently interested in meteorological work to apply for a copy.

Radcliffe Observatory, Oxford.

During the year the staff has been chiefly employed on the work of the General Catalogue of 6,350 stars for 1890, between the Equator and 115° N.P.D. There only remain 371 of these

stars which require an additional observation. The precessions and secular variations required for the formation of the catalogue have been computed, and the mean places for the different years brought up to the epoch 1890, and this part of the work is now under examination.

The Moon was observed with the transit circle at every opportunity in 1892, but the comparisons of the results with Hansen's Tables have not yet been completed. The places of the Moon observed in the year 1891, showed that the tabular error of Hansen's Tables in longitude had increased to 19″·3, and the increase had been at the mean rate of 0″·75 per annum since the end of the year 1863.

Meridian observations of *Mars* and the selected comparison stars were secured on twenty-two nights, being every available night from 1892 June 27 to September 19. The low altitude of the planet affected the definition very considerably, and must to some extent have increased the probable error of the observations.

The zenith distance and transit reductions are completed for 1892.

With the Barclay Equatoreal the following observations have been made:—Seventeen measures of eleven double stars; estimation of the magnitude of *Nova Aurigæ* on thirty-one nights; examination of the Great Nebula in *Andromeda*, and of certain stars for apparent discrepancy of magnitude; some observations of the solar spectrum. The place of Comet *Wolf* was obtained on January 6, and Comet *Holmes* was observed on 1893 January 20.

Five occultations of stars by the eclipsed Moon were secured on May 11, but further observations were prevented by the sky becoming completely overcast.

The meteorological observations have been carried on with the usual regularity.

In the month of September, Mr. F. Bellamy was appointed as assistant at the University Observatory, and his post has been filled up by the appointment of Mr. E. McClellan.

Oxford University Observatory.

The general scope of the observatory work has been unchanged during the past year. The observations for the parallax of about thirty stars, chiefly of the second magnitude, have been at length completed. The results have been published at the expense of the University of Oxford, and have been circulated among various observatories.

The work for the International Star Chart has been prosecuted to the extent permitted by indifferent weather.

An attempt has been commenced for the determination of the parallaxes of various stars in the *Pleiades*, but the position of the group in the heavens renders the work peculiarly difficult. At all events it is to be hoped that the attempt will issue in a

catalogue of the coordinates of all the stars therein up to magnitude 12.

Recently a convenient observatory has been erected, contiguous to the main building, for the exclusive use of university students. This observatory is furnished with two small transit circles, three telescopes, one of which is a reflector of 15 inches aperture, a clock, and various smaller instruments, such as sextants and spectroscopes. In this way the larger instruments in the observatory proper are reserved for research, and more serviceable instruments are provided in their stead for the purposes of instruction. This building is provided with three low-pitched roofs, two of which slide the one over the other, and both of them over the fixed roof of a room provided for the purposes of professorial instruction.

After nineteen years of most able service, Mr. Plummer has taken up his appointment as Director of the Liverpool Observatory. He leaves behind him our grateful recollections of his capabilities and zeal in the past, and our confident expectations that a very useful career lies before him in the future.

Temple Observatory, Rugby.

The usual educational work has been carried on at this observatory during the past year. Mr. Highton has continued the measurement of double stars, and has completed a considerable number of measures. Some little photography has been done on the nebulæ with a 15-inch mirror of 48 inches focus.

Stonyhurst College Observatory.

Some additions have recently been made to the apparatus of the large grating spectrometer, to meet the requirements of photography as applied to small parts of the Sun's disc, such as spots, faculæ, and prominences. The instrument and its heliostat have been already described in the Annual Report of 1891 February. Since then, a 4-inch objective (Jones) has been employed for the solar image, in place of the 6-inch (Alvan Clark) that was originally mounted for the purpose; and the image is now enlarged by a simple concave lens placed near the principal focus of the objective. This arrangement has been found more convenient than an objective of greater focal length; the image is easily brought to a focus by the sliding motion of the enlarger, without shifting the objective, and spots of moderate size are distinctly seen on the slit-plates.

The glass reflectors are now silvered for first surface reflection. Liebig's process, as modified by Mr. Brashear, has been adopted for the purpose, and has given every satisfaction. The exposed positions of the mirrors makes the re-silvering a more frequent necessity than is desirable; but the process is simple,

and the pair of surfaces can easily be renewed in an evening, and made ready for service, if wanted, on the following morning.

The photographs of spot spectra, taken in November and December, number fifteen, all in the green-yellow region. Their evidence, so far, is not conclusive, either for or against real widening of any of the solar lines over spots. But some observers find the same lines, about six in all, widened on all the plates that contain them.

About twenty plates have been exposed to the H K region, with the slit crossing the solar image over areas of faculæ. These show the reversals of H and K, and the reversals are always double, as observed by M. Deslandres and by Professor Hale. On some of the plates the reversals are traceable all along the lines, showing only intensification at the positions of the faculæ; and on three plates exposed to the Sun as a star (*i.e.* without an image on the slit) the same reversals are clearly though not strongly marked. These plates, therefore, confirm the observation of M. Deslandres recorded in the *Comptes Rendus* 1892 July 25.

The drawings of the solar spots, and the measures of the chromosphere and prominences, have been carried on as usual; but the latter observations have been made only on days which showed a fair probability of completing the measures all round the disc without much interruption. Sixty-four complete measures have been made in this way, and the spots and faculæ have been sketched on 160 days, including full drawings and outlines.

The examination of the solar drawings for the year of least activity, 1889, has been greatly interrupted during the course of the past twelve months, but it is now nearly complete. We find twenty-seven separate groups of spots for that year, and 121 groups of faculæ. Of the latter, those which were unassociated with spots were generally small and short-lived, but in number and position, as set out upon the chart, they show two remarkable polar belts in latitudes 72° north and south. The southern belt is much the more pronounced, and in general both spots and faculæ are stronger in number and extent in the southern hemisphere. Six clear cases have been found, in the same year, of small bright faculæ preceding the formation of a spot. And we have apparently conclusive evidence, from seventeen groups of faculæ in the zone between 27° north and south of the Equator, that the rotation-periods of faculæ vary with their latitudes, in strict conformity with Carrington's law for the spots. All these groups have been observed on more than one passage across the visible surface of the sun, and some during as many as four or five rotations.

The night work with the 8-inch Equatoreal has been, almost exclusively, the photography of stellar spectra. The collection of plates, from 1891 September, is a small one. About 180 photographs of 45 stars are available for wave-length measure-

ments, exclusive of many others of a purely experimental purpose. This will probably be the concluding list of operations with the 8-in objective. The new one of 15 inches, purchased with the fund raised to the memory of the late Father Perry, is expected to be in position for a new series of stellar spectra early in March.

Dr. Common's Observatory, Ealing.

During the past year a new 5-foot mirror has been made for the telescope, the disc of glass being that supplied by the Saint-Gobain Glass Co. to replace the first disc.

Very little observational work has been done. The fifth satellite of *Jupiter* has been seen on several occasions. The work on plane mirrors has been carried on, and the method of paper polishing recommended by Foucault tried with an encouraging amount of success.

Mr. Crossley's Observatory, Bermerside, Halifax.

The astronomical work of this observatory has been chiefly the measurement of double stars, the observation of the phenomena of the satellites of *Jupiter* and *Saturn*, the occultation of stars by the Moon, and transits of clock stars for time. The usual meteorological observations at 9 A.M. and 3 P.M. have also been made, and reports sent to the Registrar-General, Mr. Symons, and the local sanitary department. As Mr. Crossley has withdrawn from active astronomical work, he has decided to dispose of the 3-foot reflector and dome.

Wolsingham Observatory (Rev. T. E. Espin's).

The usual spectroscopic zone-work was somewhat interrupted in the spring by the attention given to the *Nova Aurigæ*. In zones $+55°$ and $+56°$, 116 new third-type stars were, however, detected. Amongst these one star (D.M. $+55°$. 1870) was suspected of variability; but Professor Pickering has found no variation from the Harvard photographs. In the autumn it was determined that the telescope should be entirely devoted to the revision of double stars in connection with the forthcoming edition of *Celestial Objects for Common Telescopes*, but it was not till October 1 that sufficient practice had been made to warrant the commencement of actual measurements. Between this and the end of the year 847 measures were made, observations being often carried on for 12 hours consecutively, and on one favourable night for $13\frac{1}{2}$ hours, on account of the urgency of the work. Moreover, during the measurements new companions were in many cases detected, closer than those already known. Thus Σ 306 has three comites

nearer than the one measured by Dembowski; while Σ 994, ℍ V. 66, *β Camelopardi*, were found to be more closely double. Generally the new comites are difficult objects, and are only measured with much difficulty.

The daily readings of the meteorological instruments have been continued during the year.

Dr. Huggins' Observatory, Upper Tulse Hill, S.W.

The work of this observatory during last spring was chiefly devoted to observation—both visual and photographic—of *Nova Aurigæ*. The results have been published in the Royal Society's Proceedings.

During the summer and autumn alterations were in progress in the equipment of the observatory; these have now been completed, and work has been resumed.

Rousdon Observatory, Lyme Regis (Mr. C. E. Peek's).

Observations of "long-period variable stars" have been continued during 1892. The year has been, on the whole, favourable for astronomical work, 166 nights having been available for observations: 502 determinations of magnitudes were obtained, this being considerably in excess of any of the previous six years' work. The working list includes twenty-four objects, chiefly long-period circumpolar variables, with a few, less-favourably situated, but specially interesting objects. Among the latter is *Nova Aurigæ*, which has been been examined with great attention. The nebulous and ill-defined appearance of this variable has been noticed by several observers, and has drawn special attention to the unusual characteristics of the images of many of the variables as compared with ordinary non-variable stars. This peculiarity has also been observed here with regard to several other stars for several years past.

The usual observations of clock stars have been taken.

Instrument in use, 6·4-inch equatorial refractor. Powers 34, 80, and 132.

Dr. Isaac Roberts's Observatory, Crowborough Hill, Sussex.

Photographs of stars, planets, nebulæ, and clusters of stars have been taken, as frequently as practicable, during the year ending 1892 December 31, but the number of nights sufficiently clear for long exposures of the plates has, I think, been below the average that might be expected in this locality. Moonlight also diminishes largely the number of nights that would, in its absence, be suitable for photographic work.

One hundred and twenty-two photographs, with exposures from 30 minutes to 4 hours, were obtained during the year, and also many others with shorter exposures. Of the plates with

long exposures 18 were taken in March, 26 in April, 14 in October, and 15 in December.

Ten plates of the eclipse of the Moon on May 11 were taken, with exposures from 4 seconds to 10 minutes each, and upon them the phases are well recorded.

Following is a list of the regions in the sky which have been photographed with long exposures during the year, and the plates are available for reference when required. Those marked * have been enlarged and presented to the Society, and I am engaged in preparing for publication about fifty selected photographs, with the necessary descriptive matter to accompany them, so as to make them available, at a nominal price, for the use of astronomers.

The coordinates given are those for about the centre of the plates, each of which covers 2° by 2° of the sky.

	R. A. h m	Decl. ° ′	Expos. m
Neb. near β Andromedæ	1 3½	N. 35 10	60
*Comet Holmes	0 43	„ 37 24	75 and 30
Neb. H I. 151 Piscium	1 19	„ 9 0	90
Cl. 103 M. Cassiopeiæ	1 26	„ 60 9	60
Neb. H I. 100 and II. 4 Ceti	1 27	S. 7 30	60
Cl. 74 M. Piscium	1 31	N. 15 15	90
Cl. H VI. 31 Cassiopeiæ	1 38½	„ 60 43	60
Neb. Trianguli	2 31	„ 29 41	60
Cl. 34 M. Persei	2 35	„ 42 20	60
Neb. 77 M. Ceti	2 37	S. 0 27	90
Cl. H VI. 25 Persei	3 7½	N. 46 51	54
Cl. Camelopardi	3 56½	„ 69 30	60
Neb. Star H. IV. Tauri	4 3	„ 30 30	140
Plan. Neb. H IV. Eridani	4 10	S. 13 2	60
Neb. H I. 217 Aurigæ	4 23	N. 35 3	90
Cl. 38 M. Aurigæ	5 21½	„ 35 44	60
*Nova Aurigæ	5 24	„ 30 23	5 to 3^h
*Crab Neb. 1 M. Tauri	5 29	„ 21 57	... 3^h
Cl. 35 M. Geminorum	6 2	„ 24 21	55
Sirius	6 40	S. 16 34	4 to 2^h
Neb. H I. 163 Sextantis	10 0	„ 7 12	60
Regulus	10 2	N. 12 29	90
Neb. 99 M. Virginis	12 13	„ 13 0	90
Neb. 95 M. Leonis	10 40	„ 12 18	90
Neb. H I. 13 Leonis	11 0	„ 0 32	90

	R. A. h m	Decl. ° ′	Expos. m
Neb. 66 M. Leonis	11 14	N. 13 40	90 and 4^h
Search for Planet beyond Neptune from	11 24	,, 0 0	90
to	12 12	,, 6 0	90
Neb. 98 M. Virginis	12 8	,, 15 29	90
Neb. 61 M. Virginis	12 16	,, 5 3	90
Neb. 84 and 86 M. Virginis	12 20	,, 13 30	90
Neb. 85 M. Comæ Berenicis	12 20	,, 18 46	90
Neb. 41 M. Virginis	12 24	,, 8 35	90
Neb. 88 M. Virginis	12 26½	,, 15 0	90
Neb. 87, 89, and 90 M. Virginis	12 28½	,, 13 26	... 4^h
Neb. 54 M. Virginis	12 36	,, 12 16	90
Neb. 94 M. Canum Venaticûm	12 46	,, 41 42	90
Glob. Cl. 53 M. Comæ Berenicis	13 7	,, 18 44	60
Neb. 63 M. Canum Venaticûm	13 11	,, 42 35	50
Neb. ♅ I. 34 Virginis	13 32	,, 9 26	90
Cl. 3 M. Canum Venaticûm	13 37	,, 28 55	60
Neb. 101 M. Ursæ Majoris	13 59½	,, 54 52	90 and 200
Neb. ♅ I. 215 Draconis	15 3½	,, 56 10	90
Cl. 5 M. Lyræ	15 13	,, 2 28	90
Cl. 12 M. Ophiuchi	16 41½	S. 1 45	60, 105, and 2^h
Cl. 14 M. Ophiuchi	17 32	,, 3 11	90
Cl. 26 M. Clyp. Sobieskii	18 39	,, 9 30	90
Cl. ♅ I. 47 Aquilæ	18 47	,, 8 50	60 and 120
Cl. *h* 2024 Aquilæ	18 49	N. 10 13	60
Cl. 56 M. Lyræ	19 12½	,, 30 0	... 3^h
Cl. 52 M. Cephei	23 19	,, 61 1	60
Cl. 71 M. Sagittæ	19 49	,, 18 30	90
Cl. ♅ I. 103 Delphini	20 29	,, 7 3	60 and 3^h
Neb. ♅ V. 15 Cygni	20 46½	,, 30 15	... 4½^h
Neb. ♅ V. 14 Cygni	20 52	,, 31 4	120
Neb. ♅ I. 192 Cephei	20 57	,, 54 9	90
Neb. ♅ I. 53 Pegasi	22 32	,, 33 52	219
*Neb. ♅ I. 55 Pegasi	23 0	,, 11 46	... 4^h
*Cl. ♅ VI. 30 Cassiopeiæ	23 52	,, 56 8	60

Mr. W. E. Wilson's Observatory, Streete, Co. Westmeath.

The remounting of the 2-foot reflector by Sir H. Grubb was completed about February last. A considerable number of photographs of stars have been taken, principally with the view of getting the telescope in final adjustment.

Some photographs were taken in the autumn of *Jupiter* and his satellites with the photographic photometer in order to determine the relative albedo of the planet and his moons. The results will shortly be laid before the Society.

The mirror was sent to Sir H. Grubb in November in order to make it a better fit in its cell.

A paper was read by myself and Professor Rambaut before the Royal Irish Academy in May on "The Absorption of Heat in the Solar Atmosphere." A copy of this has been sent to the library of the Society. The large siderostat kindly lent by the Royal Society to carry on experiments on solar radiation has arrived, and will be erected this coming spring.

Hong Kong Observatory.

During the past year the time-ball was dropped daily at 1 P.M. The transit observations were made with a new chronograph by Sir H. Grubb, of Dublin, which works exceedingly well. Some observations of eclipses and shooting stars were also made.

Absolute magnetic observations were made monthly.

Local, continuous, and hourly meteorological observations were made the same as in previous years. Reports were received from about forty stations on shore, a number of which were inspected during the year. Over 500 extracts of log-books of ships having encountered bad weather were copied. Daily weather-maps for the years 1888 to 1892 inclusive are ready, and are being used in the investigation of orbits of typhoons in those years. Daily weather reports and telegraphic storm-warnings were issued as usual. A number of instruments were verified.

Three years' hourly readings of tides from trace on Sir W. Thomson's automatic tide-gauge were finished, and the first two harmonically analysed by Mr. Roberts in London. These records have since been discontinued.

The eighth annual volume was issued last spring, and the ninth volume is nearly ready for press.

Lectures on spherical and practical astronomy were delivered to the staff.

The Madras Observatory.

During 1892, as for several years past, observations other than those required for the efficient maintenance of the time service have been entirely subordinated to the work of publication. During the year two volumes of the *Madras Meridian Circle Observations* and one volume of *Meteorological Results* have been published, and at the close of the year two other volumes were well advanced. The *Meridian Circle Observations* are now in type to the close of 1878, but as the observations were continued till 1887, it will probably be nearly two years more before the final catalogue can be issued. In the early part of the year the Officiating Government Astronomer made a series of comparative observations at Madras, Kotagiri, on the Nilgiris, and Kodaikanal, on the Palani Hills (7,500 feet above sea level), with the object of testing their relative merits as sites for the proposed new observatory. The general result of the observations was that Kodaikanal was far superior to either of the other two—a result since confirmed by meteorological observations.

The future of the observatory as to position, equipment, and staff is still undecided, but there seems to be good reason to hope that something will be done before long to put matters on a more satisfactory footing.

Melbourne Observatory.

The astronomical work of the Melbourne Observatory during 1892 has consisted chiefly of meridian observations and astrographic operations. Very little extra-meridional work has been done, either with the great telescope or the smaller equatoreals, beyond occasional planet or comet observations.

As regards the meridian work, the places of 3,181 stars in R.A. and 1,861 in N.P.D. have been obtained, and a list of 913 guiding-stars, for use at the Tacubaya Observatory in connection with the astrographic operations, was completed in March last and forwarded to its destination.

Considerable progress has been made with the astrographic work during the year, although it has been much hindered by somewhat unusually cloudy weather in Melbourne during the spring and summer. It is found that photographs, to fulfil the necessary conditions, cannot be obtained unless the sky is absolutely clear and free from moonlight; the slightest trace of the latter diminishes the photographic magnitudes of star images on the plates in a very marked manner. Only those nights, therefore, are used which are quite clear, and on which there is no moon. The number of Catalogue plates obtained up to date is 548. No work has yet been done with Chart plates.

Owing to large retrenchments in colonial expenditure, the

annual grant to the observatory has been seriously reduced since June, and the staff has been permanently reduced by the retirement, on pension, of the two senior assistants, Messrs. White and Moerlin. Mr. Baracchi, the third assistant, has taken up the duties of these two officers as far as possible, and, although the work of the establishment has necessarily to be considerably curtailed, it will affect the routine operations chiefly. The meridian and astrographic work will go on as usual, as will the magnetographic and meteorological work; the latter, however, being somewhat reduced in its less important details.

Regular work with the great telescope must be given up for the present, and little time can be given to any but the most important extra-meridian observations.

The routine work of the observatory, which includes meteorological and magnetic observations, distribution of time by signals and telegraph, rating chronometers, testing barometers, thermometers, linear measures, &c., and tidal observations, has been carried out during the year as usual.

Natal Observatory, Durban.

The principal work of the past year has been the observation of the opposition of *Mars* during July and August, and, as the weather was fairly favourable, it is to be regretted that the observatory did not possess the requisite instruments necessary for carrying out the observations according to the schemes suggested by either Professor Newcomb or Mr. Stone.

With the view of supplying some data in the event of unfavourable weather at the other southern observatories, care was taken to obtain the best results that could be obtained with the limited means at the observatory.

The meridian observations were made with the transit instrument firmly clamped in one position the whole evening, the difference between the declination of *Mars* and all available stars being measured with the micrometer. The field of view of the micrometer is rather more than one degree, the instrument being provided with double slipping pieces, and all stars brighter than $7\frac{1}{2}$ mag. which transited within half an hour of the planet were observed, usually five to eight each evening.

As a rule, a bisection was made as the star crossed each of seven vertical wires (20^s apart), whilst the planet was observed at the same wires, north and south limbs being taken alternately at each wire. Generally, each star was observed on seven or eight successive nights. In all observations were obtained on thirty-eight nights.

Observations for diurnal parallax were made with the equatoreal, which was kept firmly clamped in declination, whilst

differences in right ascension were obtained by the observed transit over seven wires of the planet and selected star. In all sixty-two sets of morning and evening observations were obtained.

Further progress is being steadily made in preparing for the press the Memoirs *On the Reduction of the Lunar Observations* and *The Theory of the Perturbations produced by the Planets*; and though there is much delay from the heavy pressure of official duties, and especially the routine work consequent on the absence of any qualified assistance, it will not be long before the last pages of one, if not of both, papers are written out ready for publication.

Sydney Observatory.

At Sydney Observatory the year 1892 has been cloudy and wet, and, like its predecessor, generally unfavourable for astronomical observations. From May 10 to December 22 Mr. Lenehan was away on sick leave, and Mr. Sellors had to take his place, which has seriously reduced the number of measures of double stars. Owing mainly to this it was found impossible to take special observations of *Mars* during opposition, and the weather was so unfavourable that it was impossible to get good views of the features of the planet except on two nights when the conditions were fairly good, but even then nothing was seen of the so-called "canals."

The difference of longitude between Sydney and Brisbane has been determined and found to be in very satisfactory agreement with two previous determinations. The observations and telegraphic comparisons were made from February 24 to March 1. In connection with this, Mr. R. G. McDawall's personal equation was determined during three nights.

With the transit circle 1,001 transits in R.A. have been taken, comprising 597 stars in R.A. only, and 404 in R.A. and N.P.D. These belong to the photographic zone.

Azimuth has been determined 128 times; Collimation, 272; Level, 341; Nadir, 351.

Comets Swift and Biela were observed, the former on three and the latter on six nights.

The computations of transit work have been completed up to the end of 1892, and recomputations of previous transit observations brought up to the end of 1890. The results of transit observations, with catalogues for 1879 and 1880, are printed, and 1881 is in progress. A full account of the New South Wales transit of *Venus* observations in 1874, illustrated by forty-one coloured diagrams, photographs, &c., has been published.

Meteorological results for the years 1880 to 1884 and 1890 have been printed. Rain and river results for 1890 have been

printed and published, and those for 1891 have been printed but not yet distributed.

A new edition of *Physical Geography and Climate* has been published; also some pamphlets, making in all 1,600 pages. A fully-illustrated description of the Star Camera has also been published.

A number of bromide enlargements of stellar and lunar photographs have been made, and with such good results that it is obvious that many astronomical photographs require to be treated in this way to see them to advantage. Some cheap printing process is wanted for multiplying these enlargements, which are real aids to the study of photographs.

Several photographs of Swift's Comet, one of which was presented to the Royal Astronomical Society, were taken in March, with a result that was not expected. The comet was shown by them to have eight ribbon-like rays, which were all invisible with the large equatoreal, even when the camera had revealed their existence. Some photographs have been taken of Brooks' Comet, which show the tail, but no rays like those of Swift's Comet. Four photographs of the latter show the rays. Six photographs of the Moon during the total eclipse of November 5 were taken.

During the year ninety-three nights were partially or wholly good for star-catalogue plates, and thirty-seven nights cleared enough to get a test object taken, and then clouded over. 465 star-catalogue plates were taken, 136 of test objects, 10 of comets, and 12 of *Mars*, making a total of 623. The year thus appears to have been better than 1891, during which only fifty-two nights were partially or wholly good. Three *réseaux* have been obtained from M. Gautier of Paris, but only one of these was free from pin-holes. The actual measurement of the plates has not yet been commenced.

Some experiments are in progress as to the value of photography in determining a comet's position relative to stars. Five minutes' exposure gives a good image of Brooks' Comet, and images of stars slightly elongated in the direction of the comet's motion, but capable of exact measurement.

The weather chart service has been maintained and two editions published daily. Close attention has been given to the investigation of weather conditions, and some results have been published, especially a study of the anticyclonic systems which pass over Australia and rule our weather.

Mr. Tebbutt's Observatory, The Peninsula, Windsor, New South Wales.

The year 1892 was characterised by a large proportion of cloudy nights, and yet much excellent work was done. The local time was determined on 159 nights, the number of stars observed

for this purpose with a declination not exceeding 40° being 908. The number of separate determinations for the level, collimation and azimuth errors of the transit instrument were 378, 43 and 162 respectively. There has been only one adjustment of the instrument, and that for level, during the year. The errors have been subject to small fluctuations only, and the rate of the standard sidereal chronometer has been satisfactory. The following is a statement of the extra-meridian work with the 8-inch and 4½-inch equatoreals.

Occultations of stars by the Moon were observed, comprising twenty-six disappearances at the dark and six at the bright limb, and six reappearances at the dark and seven at the bright limb. The occulted stars have, with the exception of one, been all identified, and they are nearly all stars whose positions have been well determined. I have again to acknowledge the co-operation of Mr. R. T. A. Innes, F.R.A.S., of Sydney, who has kindly sent me monthly his prediction calculations of the occultations of *Nautical Almanac* stars.

The following double stars were measured with the 8-inch telescope:—*p Eridani*, *h* 4373, *a Orucis*, *γ Centauri*, *γ Virginis*, *β Muscæ*, *h* 4634, *α Centauri*, *π Lupi*, *Lacaille* 6477, *ρ Ophiuchi*, 36 *Ophiuchi*, *Brisbane* 6556, and *γ Coronæ Australis*.

Twenty filar-micrometer comparisons of *Mars* and *ι Aquarii* were obtained with the 8-inch equatoreal on November 4. The objects were not seen till after the conjunction in R.A., but it was quite obvious that no occultation could have taken place at the Observatory. The star forms one of Herr Berberich's list in No. 3073 of the *Astronomische Nachrichten*.

Swift's Comet I. 1892 was observed on March 10, 21, 22, 26; April 9, 10, 11, 12, 13, 14, 15, 16, 22, 23, 30; May 1, 2; the number of comparisons being 246, and that of the comparison stars 29. Winnecke's periodical Comet was picked up on June 12, but as it was then in pretty high north declination, no observations were attempted. After its conjunction with the Sun, however, it was observed on July 17, 19, 20, 21, 22, 23, 24, 27, 28, 29; August 2, 3, 15, 23, 25, 26, 27; September 16, 17, 18, 20, 22, 26, 27. 248 comparisons were made, in which twenty-nine comparison stars were employed. Holmes' Comet was observed on November 13, 15, 18, 19, 20, 22, 23, 24. The observations comprise fifty comparisons and five comparison stars. Brooks' Comet of August 28 was observed on November 28, 29; December 8, 9, 12, 13, 14, 15, 20, 21, 23, 24, 28, 29, the number of comparisons being 177 and that of the comparison stars 23. Observations were continued after the close of the year, but these will properly be accounted for in the Report for 1893. Tempel's Comet II. 1867 was searched for between R.A. $17^h\ 30^m$ and $18^h\ 50^m$, and the parallels of twenty-five and thirty-two degrees south declination on June 19. Although the sky was brilliantly clear and the Moon absent no trace of the Comet could be found.

A few observations of the phenomena of *Jupiter's* satellites were made, and a few estimations were also obtained of the magnitudes of η *Argûs* and *R Carinæ*. The meteorological observations have been carried on as usual, and the Abstracts of Results for 1886, 1887, 1888, 1889, and 1890 widely distributed. The whole work of observation, both in the astronomical and in the meteorological departments, and the greater portion of the reductions, have been done by the proprietor himself. All the instruments remain in good order, and the library has been greatly enriched by valuable donations.

Notes on some Points connected with the Progress of Astronomy during the past Year.

[In the present Report an attempt has been made to give a list of discoveries during the year, not only in the cases of minor planets and comets, but those of double stars, variable stars, &c. It is probable that, on this occasion, these lists are far from complete, and it would very materially assist the Secretaries if discoverers themselves would furnish accurate information for future Reports, and corrections of any inaccuracies or omissions in the present.]

Discovery of Minor Planets.

The number of minor planets has been increased by twenty-nine during the past year, this rapid increase being due to the introduction of photography as a means of search, which has proved very effective in the hands of Herr Wolf and M. Charlois. The following is the list of discoveries:—

No.	Name.	Date of Discovery, 1892.	Discoverer.	Place of Discovery.
324	...	Feb. 25	Palisa	Vienna
325	Heidelberga	Mar. 4	Wolf	Heidelberg
326	Tamara	19	Palisa	Vienna
327	Columbia	22	Charlois	Nice
328	Gudrun	18	Wolf	Heidelberg
329	Svea	21	,,	,,
330	Ilmatar	19	,,	,,
331	...	Apr. 1	Charlois	Nice
332	Siri	Mar. 19	Wolf	Heidelberg
A	Badenia	Aug. 22	,,	,,
C	Roberta	Sept. 1	Staus	,,
D	...	19	Charlois	Nice
E	...	22	,,	,,
F	...	25	,,	,,
G	Dorothea	25	Wolf	Heidelberg
H	...	25	,,	,,
J	...	25	,,	,,

No.	Name.	Date of Discovery, 1892.	Discoverer.	Place of Discovery.
K	...	Oct. 17	Wolf	Heidelberg
L	...	Aug. 23	„	„
M	...	Nov. 15	Charlois	Nice
N	...	15	Wolf	Heidelberg
O	...	23	Charlois	Nice
P	...	25	„	„
Q	...	28	„	„
R	...	28	„	„
S	...	Dec. 8	„	„
T	...	9	„	„
U	...	14	„	„
V	...	16	Wolf	Heidelberg

In consequence of some tendency to confusion in the numeration of new planets, it has been decided to provisionally distinguish new discoveries by letters assigned in the order in which the news of the discovery reaches the Centralstelle. Permanent numbers will be subsequently assigned to those planets of which a sufficient number of observations is available to satisfactorily determine the orbit.

In the above list B is missing since the planet thus designated was discovered to be identical with (163) *Erigone*.

According to Berberich, No. 324, when in opposition in perihelion, will be brighter than the 8th magnitude. The tardy discovery of such a conspicuous member of the group is remarkable.

305 has been named *Gordonia*, 307 *Nike*, 308 *Polyxo*, 310 *Margarita*, 311 *Claudia*, 312 *Pierretta*, 320 *Katharina*, 322 *Phœo*, 323 *Brucia*.

In the case of photographic discoveries the date given is that of the earliest photograph on which the planet appears. It was in many cases not noticed on the plate till considerably later, which accounts for the departures from chronological order in the column headed "Date of Discovery."

The discoveries are all by photography with the exception of Nos. 324, 326, 327, 331.

Permanent numbers have just been assigned to planets A to L as follows:—A 333, C 335, D 336, E 337, F 338, G 339, H 340, J 341, K 342, L 334, M 344, N 343. A. C. D. C.

The Comets of 1892.

Including the periodical comet of Winnecke, seven comets have been discovered during the year.

(*a*) Discovered by Professor Lewis Swift, of Rochester, New

York, on the morning of 1892 March 7, the comet at the time having considerable southern declination. It was sufficiently bright at the date of discovery to be visible to the naked eye, and although there was no great increase in the theoretical brilliancy, it nevertheless became a very conspicuous object in the morning sky, the length of the tail being estimated by various observers at 10°, 11°, and even 20°, while the nucleus shone as a star of the third magnitude. Very successful photographs were taken at the Lick Observatory by Professor Barnard, which exhibited "creases, knots, and bends in the streams of luminous matter, apparently flowing out from the head and forming the tail." The diminution of brilliancy from the head to the extremity of the tail was not uniform.

The course of the comet was through *Aquarius*, *Pegasus*, and *Andromeda*, and observations pursued through several months (it was seen at Bordeaux on November 20) showed that the path of the comet deviated sensibly from the parabola. Dr. Berberich found that the observations are best represented by an ellipse of about 2000 years' period; and it is possible that the slight difference from parabolic velocity was produced by an approach to *Saturn* about 1887, but this point cannot be decided till the definitive elements have been computed.

(*b*) On March 18, Mr. Denning, of Bristol, detected a faint comet near δ *Cephei*, and, as the elements have shown, at a very considerable distance both from the Earth and Sun. Owing to these relations the comet remained small and inconspicuous, but observations have been possible through a considerable period, and in large telescopes the object is probably still visible. The observations, as at present discussed, do not exhibit any signs of ellipticity in the orbit.

(*c*) A return of the comet of Winnecke. Dr. Spitaler's long search for this comet, continued at favourable opportunities since 1891 February, was rewarded by success on March 18, the comet then being more than three months before perihelion passage. The position predicted by Dr. Haerdtl, whose admirable researches on the theory of this comet are well known, was in error only half a minute in the arc of a great circle, and this close agreement between theory and observation diminishes the probability that a faint cometary object, seen by Dr. Spitaler more than a year previously, was really Winnecke's comet, since this suspicious object was some twelve minutes from the path computed by Dr. Haerdtl.

Observations were possible in the Northern Hemisphere till June, the brilliancy constantly increasing, but the position for observation less favourable as the comet approached the Sun. On emerging from the Sun after perihelion passage, the comet was more favourably situated for observations in the Southern Hemisphere, where it has been well observed.

(*d*) On August 28 Mr. Brooks, of New York, detected a faint telescopic comet in Gemini, some four months before its

perihelion passage. The comet was, therefore, increasing in brilliancy, and before the end of the year became a conspicuous object with a well-developed tail. The great southern declination, however, into which the comet has moved, has prevented the accumulation of observations in the Northern Hemisphere. A parabolic orbit represents the path of the comet with great accuracy.

(*e*) The discovery of this comet is particularly interesting, owing to the fact that it was detected on a photographic plate, and is the first so discovered, if we except the somewhat doubtful record of a comet on plates exposed during a solar eclipse. The discovery is due to Professor Barnard, who on October 12 exposed a plate for a considerable time to the neighbourhood of *a Aquilæ*. On developing, a trail was observable, which was conjectured to have been impressed by a comet, and on the first favourable opportunity the comet was easily picked up, about two degrees from the place marked on the photographic plate. The elements also are interesting, since pronounced deviation from parabolic motion was at once evident. With elements computed from only five days' observations it was impossible to represent the middle longitude within half a degree; and, further, the elements showed great similarity to those of the periodic comet of Wolf. Dr. Schulhof called attention to the extreme probability of the two comets having formed part of one body, presenting a similar case to that of Biela and Brooks' comet, 1889, V. This conjecture is still further strengthened by the application of Tisserand's well-known criterion, where, following the usual notation, we have:—

$$\frac{1}{a} + \frac{2\sqrt{A_J}}{R^2_J}\sqrt{p}\cos i. =$$

for Comet Barnard	0·495
„ „ Wolf, 1891	0·497
„ „ „ 1875	0·492

With a particular value of the period, not greatly different from that assigned by Dr. Schulhof, it would be possible that the comet should be near *Jupiter* in 1875, when Wolf's comet was also within the sphere of that planet's attraction; but the close agreement of these figures seems to indicate that the orbit is very exact, and that such alteration of the period is not permissible. This would indicate that the separation of the two bodies was probably earlier than 1875, but the decision of this point must be left till the orbit is definitely determined. It is unfortunate that the feebleness of the comet has prevented a very long series of observations. It was seen at Nice at the beginning of December, and may still be within the reach of the largest telescopes.

(*f*) On November 6 Mr. Holmes, of London, discovered a

bright comet in the constellation *Andromeda*, and the same comet appears to have been independently discovered in Queensland on November 9 by Mr. Davidson. The comet is described by the discoverer as 5′ in diameter, and bright enough to be seen by the naked eye. The greatest theoretical brilliancy occurred in the latter portion of September, when the comet should have been rather brighter than on November 6, and well situated for observation in the Northern Hemisphere. It is therefore remarkable that so bright an object was not sooner detected, but this comet seems to have exhibited greater fluctuations in brilliancy than any other comet. Dr. Palisa has telegraphed that the present appearance of the comet (January 18) is that of a star of the eighth magnitude surrounded by a nebulosity extending not more than twenty seconds in diameter. Since this outburst has occurred, after the comet had become invisible in ordinary telescopes, it is not improbable that a similar outburst occurred shortly before November 6. Such variations of character would explain the non-appearance of the comet on the photographic plates that have been certainly exposed to the sky in the situations the comet was occupying, for though suspicions have been entertained of the photographic impression of the comet, yet, when submitted to exact calculation, the deduced position from the photographic plate has not given an entirely satisfactory result.

Such variations of brilliancy would explain the fact that the comet had not been seen at some earlier return, for the orbit has proved itself to be one of short period, and it is probable that the comet has made more than one return to the Sun in practically the same orbit. Subsequent inquiry has shown that it is not impossible that Holmes' comet belongs to the same family as that of De Vico, 1844, I.

(*g*) The last cometary discovery of the year was effected by Mr. Brooks, who perceived a bright comet in the constellation of *Boötes* on the morning of November 19. Its steady increase in brilliancy, coupled with its northerly motion, made it a tolerably easy object for observation. Since the perihelion passage falls in 1893, this comet will appear in the catalogues of that year. W. E. P.

The Fifth Satellite of Jupiter.

The astronomical event of the year is undoubtedly the discovery of a fifth satellite to *Jupiter*, made at the Lick Observatory, California, on Sept. 9, at midnight, by Professor E. E. Barnard, who, while carefully examining the neighbourhood of *Jupiter* with the 36-inch, detected "an exceedingly small star" close to the planet and near the third satellite, which he at once suspected to be a new satellite, a suspicion soon verified. The discovery was the result of a systematic search for new objects instituted by Professor Barnard.

The satellite has since been frequently observed and measured at the Lick Observatory. Professor Barnard has occasionally been able to follow it to within 8″ of the planet's limb, but remarks that, examining it under the best conditions with a high power, he has never seen it other than as a star, nor has he been able to catch the slightest glimpse of its shadow when in transit. In all his later observations a piece of smoked mica has been used in front of the eye-lens to dull the light of *Jupiter*, the planet and satellite then being readily seen at the same time. Nearly all his observations were made at east elongation.

The following elongations were observed among others:—

September 10, $20^h\ 49^m{\cdot}0$, east elongation.

October 21, $17^h\ 2^m{\cdot}8$, east elongation.

October 23, $16^h\ 49^m{\cdot}0$, east elongation.

From the first two a period of $11^h\ 57^m\ 20^s{\cdot}5$ results.

From an elongation on October 28 the period was computed as $11^h\ 57^m\ 17^s$.

The mean of ten measured east elongations, reduced to the mean distance of *Jupiter*, between September 10 and October 28 is $48''{\cdot}10 \pm 0''{\cdot}011$, while the mean of four (including a discordant one) west of the planet gives $47''{\cdot}42 \pm 0''{\cdot}042$, the probable error of a single observation being $\pm 0''{\cdot}11$ and $\pm 0''{\cdot}17$. These two values represent a distance from *Jupiter's* centre of 112,520 miles and 110,930 miles respectively.

The west elongations are about 1″ less than the eastern, so that the orbit is apparently elliptic. The measures for latitude seem to show that the satellite's orbit lies sensibly in the plane of *Jupiter's* equator, which would signify that it is not a recent addition to the Jovian family.

The fifth satellite has also been observed at a few other observatories possessing instruments of sufficient calibre. Professor Stone has seen and measured it with the 26-inch at the University of Virginia. At Princeton it was observed on several occasions between October 10 and 29 by Mr. Reed, Professor Young's assistant, who, however, was unable to obtain any complete set of measures embracing both sides of an elongation. His observations point to a period of $11^h\ 57^m\ 23^s$, with an error probably less than 10 secs. Mr. Reed stated that he found it an easier object than *Ariel*, the inner satellite of *Uranus*, which reverses the experience of Professor Hough, who saw it with the 18½-inch at Evanston, Illinois, and reported it much more difficult than *Ariel* and *Umbriel*. The satellite was also observed with Dr. Common's 5-foot reflector at Ealing, on five occasions between October 18 and December 26, but no measures are reported. On December 13, at $6^h\ 55^m$, Mr. Taylor observed it in conjunction with the first satellite, which was below the fifth. On December 25 and 26 it was seen when at W. elongation between 5^h and 6^h G.M.T.

A full account of the discovery was given by Mr. Barnard in the *Astronomical Journal*, No. 275, 1892 October 4, together with

all his micrometer measures obtained from September 9 to 16. Later details were given in a paper communicated to the R.A.S. meeting 1892 November 11.

Mr. Marth, in his second provisional ephemeris (1892 December 1 to 1893 January 28), has adopted $11^h\ 57^m\ 37^s$ as the period. A. E.

Nova Aurigæ.

On February 2 the following circular was issued from the Royal Observatory, Edinburgh:—

"Yesterday an anonymous postcard was received here, bearing the following communication:—*Nova* in *Auriga*. In Milky Way, about two degrees south of χ *Aurigæ*, preceding 26 *Aurigæ*, fifth magnitude, slightly brighter than χ *Aurigæ*.

"At $6^h\ 8^m$ G.M.T. the star was easily found with an opera-glass. It was of a yellow tint and of the sixth magnitude, being equal to 26 *Aurigæ*. Examined with a prism between the eye and the eye-piece of the 24-inch reflector, it was immediately seen to possess a spectrum very like that of the *Nova* seen in 1866. The C line was intensely bright; a yellow line about D fairly visible; four bright lines or bands were conspicuous in the green; and, lastly, a bright line in the violet (probably Hγ) was easily seen. A telegraphic notice was sent to Greenwich in the afternoon, and, later on, when the true nature of the object was recognised, to Kiel, for general distribution. The star was photographed last night at Greenwich. Its place for 1892 is $5^h\ 25^m\ 3^s + 30°\ 21'$. It does not occur in the Bonn maps."

Dr. Thomas D. Anderson, the author of the postcard to Professor Copeland, is an amateur astronomer living in Edinburgh, and he discovered the new star by means of a star-atlas and a small pocket-telescope. In a letter to *Nature*, 1892 February 18 (p. 365), he announced that the star was visible as of the 5th magnitude for some days before the postcard was despatched to Professor Copeland. The previous history of the star was, by singularly good fortune, partly recovered from photographs taken at Harvard College. Professor E. C. Pickering, the Director, recently conceived the idea of "patrolling the heavens," every fine night, by means of a small photographic transit instrument, which automatically sweeps the meridian in a series of steps of sufficient exposure to photograph 6th-magnitude stars, at intervals corresponding to the equatorial breadth of the field. The scheme is perfectly adapted for the detection of strange objects brighter than the 6th magnitude, and its merits were thus clearly demonstrated within a few months of its inception. The *Nova* was found on thirteen photographs taken on December 10, 11, 13, 17, 18, 18, 28, 30, January 5, 8, 9, 16, 20. It does not appear on a photograph taken at Heidelberg on December 8, showing stars to the 9th magnitude.

After remaining of the 4th or 5th magnitude till the end of

February, the *Nova* diminished somewhat rapidly in brightness, and by the end of March was of the 12th to 14th magnitude. Photometric observations were made by many observers, and both visually and photographically; and the comparison of the different series should give valuable results, especially the study of the discrepancies between photographic and visual magnitudes with special reference to the changes in the spectrum mentioned, below. No detailed comparison has, however, yet been made. The star was followed visually at the Lick Observatory until April 26, when a three weeks' storm interrupted observation. Its magnitude is then given as 16·2.

After thus practically disappearing, the *Nova* was found to be again easily visible in August. At the Lick Observatory it was found to be of magnitude 10·5 on August 17, and 9·8 on August 19. The brightening was detected independently in England by Mr. H. Corder about the same time, but the first published observation is that of Mr. Espin (to whom Mr. Corder had written), on August 21. The star is now of about magnitude 12, and fluctuations in brightness have occurred, which indicate that it must be carefully watched in the future.

The Spectrum and Spectroscopic History of Nova Aurigæ.

It was to be expected that no pains would be spared to make the spectroscopic study of the *Nova* of 1892 as complete as possible. Its spectrum was the first consideration at every observatory, and from all the observers came the same notice of a brilliant array of bright broad lines.

It soon became clear that the bright lines were not the only features of the spectrum: it was simultaneously noted at Tulse Hill, South Kensington, and Stonyhurst, and first announced by Professor Lockyer, that the bright lines were attended by dark companions on the more refrangible sides. Numerous finer details were then added to the spectrum, dark lines crossing the broad bright bands, and bright lines marking the dark companions; and it was found that there were changes in progress amongst these more delicate parts of the spectrum. A careful watch was kept upon the stronger lines to note any changes in them, whether of their position or width; but up to the last appearance of the lines, in the waning light of the star, they showed the same broad front.

The analysis of the spectrum has been conducted with great care at many observatories by comparisons with terrestrial radiations, with the spectra of other stars, and with carefully-constructed wave-length charts for the instruments employed. There is a want of accord between the results from the several observatories, which is in part, no doubt, due to the great width of the lines under observation; but the collective evidence upon the details of the spectrum has yet to be studied, and this is hardly

possible without a very full description of each line and of the instrument in use.

Three of the lines, however, have attracted more attention everywhere on account of their intimate connection with the suspected physical constitution of the star. These are (1) the bright-green line near b_4, and the less refrangible edge of the hydrocarbon band; (2) the line near to the chief nebular line λ 5006; and (3) the line near to the pair of chromospheric lines λ 4923 and λ 4921. When the wave-lengths of these lines, as quoted by the observers, are corrected for motion in the line of sight, and arranged in a table, the mean values come out very closely as the wave-lengths of three notable pairs of solar chromospheric lines; while magnesium and the hydrocarbons, as possible origins of line (1), are excluded by the absence from the lists of their inseparable companion-lines and flutings.

Line (2) is claimed by four observers for the chief nebular line, the mean of their measures being 5005; but the majority is a very strong one against it, the mean of eight measures being 5015, and Huggins, Vogel, and Young, who have made a special study of this line, have pronounced emphatically against its nebular origin, independently of the absence of its mate at λ 4957.

Thus, by the successive exclusion of previously suspected origins, the outburst of light in the *Nova* came to be recognised as a vast chromospheric disturbance; a view confirmed by Dr. Huggins's discovery, on February 22, of the complete series of bright hydrogen lines in the ultra-violet—the same that Hale and Deslandres discovered in the solar chromosphere,—but each with its dark companion.

In studying the character of individual lines it was necessary to determine whether the wideness should be attributed to a single or to a multiple origin. The two strong hydrogen lines at F and G′ were certainly divided by a faint dark line near the centre of each; and the two parts might belong to separate sources of hydrogen, or to hydrogen and some other incandescent gas. The separation, centre from centre, of the broad bright line and its dark companion at F already showed an enormous relative velocity of the origins; it could not be less than 500 miles in the second. The subdivision of the lines into separate hydrogen flames would introduce a much greater velocity. Dr. Huggins, however, drew attention to the similar double, and in some cases triple, reversals obtained in the laboratory by Professor Liveing and Dewar as furnishing a more probable explanation of the apparent subdivisions. This has been accepted as probably the true account of most of the finer details of the spectrum; and the supposition has been greatly confirmed by the solar photographs at Paris, Chicago, and Stonyhurst, which show these reversals on the bright faculæ which belong to the solar chromosphere. There remained, however, some uncertainty about the position, in the broad line, of the origin of the widen-

ing; for in the laboratory the widened lines were not always found with equal parts on both sides of the true line. But the true position was always marked by a maximum intensification; and Professor Vogel found a like position in the hydrogen F of the *Nova*. Measuring, therefore, from this centre, the Potsdam line-of-sight spectrograph gives, with reference to the earth, a receding velocity of 230 miles to the bright hydrogen, and an approaching velocity of 320 miles in the second to the origin of the dark lines.

The difficulty of accounting for these extraordinary velocities has been felt by all astronomers. A single star at such a speed would only mean the addition of one to our small list of known high-speed wanderers; but two in the same line of sight, and maintaining their velocities unchanged for seven weeks, postulates either an all but inadmissible chance meeting, or a system under the control of a distant mass too great to leave the universe of stars at apparent rest.

It is not possible here to do more than to refer the reader to the authors of the several explanations offered during the year. The meteoritic theory by Professor Lockyer is outlined in the *Nineteenth Century*, vol. xxxi. The chromospheric theory of the near approach of two stars is given by Dr. Huggins in the June number of the *Fortnightly Review*; Seeliger's modification of the meteoritic theory is translated in *Astrophysics* for December from *A.N.* 3118; and a single-star chromospheric theory is offered by the Rev. W. Sidgreaves in the October number of the *Observatory*.

The revival of the star in August has added to its mysteries. The new spectrum is claimed by Professor Campbell and by Herr E. von Gothard to be that of a planetary nebula with a displacement towards the blue of five tenth-metres. Its light is, however, too feeble for the measures of the wave-lengths of the lines observed to be implicitly accepted, and it is premature to discuss the question until time shall have shown whether the star be merely a "temporary" one, or one with a variation between the tenth and seventeenth magnitudes. W. S.

Variable Stars. Discovered at the Harvard College Observatory during the year 1892, *by Mrs. Fleming, in the regular examination of stellar spectra.*

Constell.	R.A. h m	Dec. ° ′	Gr. Br.	Lt. Br.	Description.
Horologium	2 49·7	−50 21	6 2	9·7	Type III., hydrogen lines bright
Octans	5 56·8	−86 26	7·4	< 11·3	,, ,,
Boötes	14 22·3	+ 5 7	8·2	10·7	,, ,,
Libra	15 18·5	−22 34	8·4	< 11·0	,, ,,
Scorpius	16 56·8	−36 46	8	< 11	,, ,,
Octans	17 25·9	−86 46	8·2	< 11·7	,, ,,
Sagittarius	19 49·8	−29 27	7·5	< 12·6	,, ,,
Tucana	23 52·2	−65 56	10·2	< 12·6	,, ,,

The sixth star in the above list is A.G.C. 27271 Mag. 8½.

The letters A.G.C. in the above lists are used to indicate the Argentine General Catalogue.

These stars were all discovered from the presence of bright hydrogen lines in their photographic spectra. No stars are included of the variability of which there is any doubt, and in every case the change exceeds two magnitudes.

New Double Stars, discovered in 1892, *and measures.*

[*The following are all due to Mr. S. W. Burnham.*]

	Star.	R.A. h m s	Decl. ° ′	P °	D ″	M	1800+	
1267	...	5 27 22	+30 51	217·9	0·84	8·5... 8·5	92·13	...
1268	24 Musc.	7 9 11	+ 0 3	313·2	3·81	6 ...11·8	92·21	...
1269	44 Hydræ	10 28 18	−23 8	63·8	18·33	5 ...14	92·23	...
1270	LL. 25825	13 57 46	+ 9 14	329·7	0·27	8·2... 8·3	92·27	...
1271	Rad. 3181	14 13 4	+55 6	355·2	2·81	6·8...12·0	92·36	...
1272	...	14 13 21	+49 18	132·5	1·25	8·4... 9·5	92·17	A B
...	...	...	...	321·8	23·67	... 8 6	92·17	A C = H 2710
1273	...	14 14 2	+48 28	193·0	1·08	8·6... 9·8	92·17	...
1274	B.A.C. 6216	18 12 35	+56 33	147·1	0·88	9·8...10·6	92·37	B and C
...	...	...	...	8·5	5·03	...10·4	92·37	B and D
...	...	...	...	239·1	95·61	6·4...	92·35	A and B

New Nebulæ discovered by Lewis Swift at Warner Observatory, Rochester, New York.

1892.	R.A. h m s	Decl. ° ″		
Mar. 28	9 35 50	+12 56·0	*ee*F, *es*, almost stellar	
Apr. 16	10 55 35	+11 3·2	*ee*F, *vs*, *ee* diff. N.G.C. 3492 near.	4th of 4
18	11 22 30	+59 9·2	*vs*, close D with 3690 = H 247·1 suspected with 132, ver. with 200.	
May 16	14 14 12	− 3 58·4	*p*F.S.R. star with distant companion near *s*.	*p* of 2
16	14 14 30	− 3 57·4	*ee*F.S.R. *e* diff.	*f* of 2
17	14 34 50	+ 3 50·0	*e*F, *vs*, little elongated.	1st of 3
17	14 35 4	+ 3 56·0	*ee*F.S.R. close D with 5718.	2nd of 3
June 16	15 52 50	+12 23·8	*ee*F, *ps*, R. in centre of rhombus of 4 stars, *v* diff.	

Stars having Peculiar Spectra. Discovered at the Harvard College Observatory during the year 1892, by Mrs. Fleming, in the regular examination of stellar spectra.

Designation.	R.A. 1900. h m	Dec. ° ″	Mag.	Description.
B.D. +53° 379	1 38·8	+53 28	9·4	Type IV.
A.G.C. 9326	7 14·8	−36 33	5·3	F line bright
A.G.C. 10963	8 9·7	−35 35	5·3	,,
...	10 7·6	−60 8	...	Type V.
...	10 13·3	−57 24	...	,,
A.G.C. 14691	10 40·3	−59 12	8½	,,
...	10 43·4	−58 41	...	,,
...	10 47·3	−61 46	...	,,
A.G.C. 14971	10 52·2	−59 55	7¾	,,
...	10 55·8	−57 17	...	,,
...	11 55·2	−54 33	...	,,
...	13 24·3	−61 34	...	,,
*A.G.C. 20937	15 21·9	−24 49	6¼	Peculiar
...	15 55·0	−62 28	...	Type V.
B.D. +9° 4369	19 56·3	+ 9 14	8·7	Type IV.

Discovered by Mr. A. E. Douglass, at Arequipa, Peru.

A.G.C. 16710	12 9·1	−50 45	8⅓	Type IV.
A.G.C. 19254	14 7·4	−53 28	7·5	Type IV.

The spectrum of this star resembles that of the well-known gaseous nebula surrounding 30 *Doradus*, which is unlike that of ordinary gaseous nebulæ.

The Direction of the Solar Motion.

The most important addition to the literature of this subject, during the year, has been contributed by Professor J. G. Porter, of Cincinnati, who has availed himself of the proper motions given in the Catalogue of 1340 stars, published in number 12 of the Transactions of that Observatory. The author has followed the method indicated by Dr. Schönfeld in the V. J. S. xvii. p. 256, without any important alterations. He has divided his stars into four groups, according to the amount of the annual proper motion, and thus has four distinct determinations based upon the following data:—

Group I.	576 stars	proper motion less than	0″·3
,, II.	563 ,,	,,	between 0″·3 and 0″·6
,, III.	142 ,,	,,	between 0″·6 and 1″·2
,, IV.	70 ,,	,,	greater than 1″·2

The complete solution of the equations of condition should exhibit the change of the galactocentric longitude of a star, measured in the plane of the Milky Way, but as in the case of Dr. Stumpe's investigation, the author has found it advisable to make this term equal to zero.

Rejecting this term, the co-ordinates of the apex of the Sun's way are derived separately from the proper motions in R.A. and Dec., and although the disagreement in the results is in some cases very noticeable, yet the directions derived from the two, when combined by means of the weights which Professor Porter has determined, are in fair mutual agreement in the whole four groups and accord with the results of previous researches.

The following positions are assigned to the apex of the Sun's way :—

	Right Ascension.	Declination.	Annual Motion.
Group I.	281°·9	+53°·7	0″·16
„ II.	280·7	+40·1	0·30
„ III.	285·2	+34·0	0·55
„ IV.	277·0	+34·9	1·66

These results generally confirm those derived by Dr. Stumpe, which will be found in the *Monthly Notices*, vol. li. p. 246, and where the "Annual Motion" has the same significance as in this case.

Professor Vogel has also published the results of a very interesting inquiry on this subject, based on the measured velocities of stars in the line of sight. The motion of fifty-one stars has been determined at Potsdam, and since the probable error in the measurements is below 1·16 geographical miles, the data seem sufficient for a determination, not only for the velocity of the solar motion, for which the observations are particularly well adapted, but also for the position of the apex of motion. The inquiry has been effected by Dr. Kempf by two different methods, but the resulting position of the apex is in neither case in very satisfactory accord with other investigations, indicating probably that the inquiry is premature, and based upon an insufficient number of stars. If the stellar motions be treated either with equal weights, or weights approximately proportional to those assigned by Dr. Vogel in his catalogue of proper motions, the co-ordinates of the apex are as follows :—

α . . . 206°·1 ± 12°·0

δ . . . +45·9 ± 9·2

Velocity . . . 11·60 ± 1·85 geographical miles.

If, however, the neighbouring stars, such as the bright stars of *Ursa Major* and of *Orion*, be combined into groups, the position of the apex is still further from that generally assigned, viz. :—

α . . . . $159°.7 \pm 20°.2$

δ . . . . $+50°.0 \pm 14°.3$

Velocity . . . . 8·11 ± 2·04 geographical miles.

If, again, the position of the apex as given by L. Struve ($\alpha = 266°.7$, $\delta = +31°.0$) be assumed, and only the velocity of the solar motion be derived, this value becomes $7·69 \pm 1·85$ geogr. miles. W. E. P.

Solar Activity in 1892.

Though the point of maximum solar activity has probably not yet been reached, the increase in every kind of solar phenomenon has been so rapid during the two past years that already the numbers recorded during the maximum of 1882–4 have been equalled, and in some points surpassed.

To begin with, there have been no days on which the Sun has been free from spots in 1892, as against three in 1882, and eight in 1883. Then the great group of 1882 November, the largest of the past cycle, only attained an area of 2,425 millionths of the Sun's visible hemisphere, as measured on the Greenwich photographs, whilst the group of February last, at its greatest extent, covered 3,528 millionths. So far, too, as the records of the year are as yet available, it would appear that the mean daily spotted area was fully as large as for 1883, the most prolific year of the last maximum.

The most remarkable group of spots of the year was, of course, that of February, but the last ten days of April, the month of July, and the early part of October were also especially distinguished by the number and size of the groups then seen upon the disc.

The reports of Professor Tacchini show that the prominences have taken part in this revival, the mean daily number observed being greater by one-third than in 1891, and the mean extent of each has increased in about the same proportion. Several individual outbursts of extraordinary violence have also been recorded. Of these, two were associated with the great sun-spot of February, one of the two, the prominence seen by M. Fényi on February 19, attaining a height of more than 2′ of arc, and being of the most remarkable brightness. Another prominence watched by the same observer on May 5, rose rapidly from the limb of the Sun, and at its greatest elevation attained a height of more than 9′. M. Trouvelot also has recorded some striking instances of prominences of unusual size or speed of motion.

The distribution of the spots in solar latitude furnishes a useful indication of the progress which the cycle has made; and during the past year the great majority of spots have been included in the two zones 10°–30°, with a growing tendency on

both sides of the equator towards the lower half of the zone. As yet, however, the mean distance of all spots from the equator is not nearly so low as 13°, the position recorded in 1883. Both spots and faculæ have, according to MM. Marchand and Guillaume, been distributed nearly equally between the two hemispheres, the northern hemisphere having a slight advantage. This circumstance also, if the precedents of the last cycle be followed in this, would show that the maximum still lies before us.

Prominence Photography.

The suggestion of M. Deslandres, noted in the report of the Council last February, that it might be possible to photograph the entire chromosphere at a single exposure, has been carried into actual effect during the past year by Professor G. E. Hale. The instrument Professor Hale has devised for the purpose, and which he has entitled the "spectroheliograph," possesses as its essential feature an arrangement driven by a clepsydra, by which the slit of the spectroscope is made to travel across the image of the Sun, and a precisely similar motion, but in an opposite direction, is given to a second slit nearly in the focus of the view telescope, and so arranged that the K line of the spectrum of the fourth order falls upon it. Since the K line is always bright in the spectrum of the chromosphere and prominences, it is easy, by shutting off the image of the Sun by means of a diaphragm, to build up a complete picture of the entire chromosphere and prominences, and so to produce what may be described as an "artificial total solar eclipse."

The discovery which Professor Hale has made that the H and K lines are always reversed in the faculæ has enabled him to extend the application of this principle. If the diaphragm, covering the image of the Sun, be discarded, a photograph will be obtained, not merely of the chromosphere and prominences, but of the disc of the Sun itself, showing the spots and the faculæ, the latter being depicted not merely when near the limb of the Sun, but wherever they occur, even in the very centre of the disc. In this manner it has been discovered that faculæ invisible to the eye frequently float above the spots, and one series of photographs in particular, copies of which have been presented to the Society by Professor Hale, show how, on July 15, a luminous outburst formed, spread, completely hid a large group of spots, and passed away, all in a few minutes of time.

The *double* reversal of the H and K lines from faculæ, a phenomenon shown upon photographs taken at Kenwood, Paris, and Stonyhurst, is a discovery of special interest as bearing upon the interpretation of the enigmatical spectrum of *Nova Aurigæ*, and Professor Hale has supplemented this discovery by obtaining a similar result with an integrating spectroscope, the Sun being

treated as a star would be, its light as a whole, and not only from special regions of the disc, being subjected to examination.

M. Deslandres, with a spectroscope from which glass had been excluded, has continued his researches on the ultra-violet spectrum of prominences, and has succeeded in securing as bright lines in the spectrum of a specially brilliant prominence not only the entire series of hydrogen lines photographed by Dr. Huggins in the spectra of stars of the *Sirius* type, but also five other lines which, from their conformity to Balmer and Ames's formula, may be concluded to belong to the same element. The same prominence yielded also lines due to aluminium, iron, and magnesium, besides many others the sources of which have not yet been determined.

M. Deslandres is also at work upon a yet more interesting research, the photographing the corona apart from an eclipse. The principle upon which he proceeds is to obtain photographs of the Sun from light of limited refrangibility, not by using coloured media or stained plates, but by means of two prisms, the second of which is arranged so as to recompose the light dispersed by the first. But only certain rays from the first prism are allowed to fall on the second; the resulting image of the Sun is therefore confined to these rays, which can be selected at pleasure. M. Deslandres's purpose is therefore to find out for what rays the corona has the greatest brightness as compared with that of the Sun, and to photograph the Sun and its surroundings by their aid alone. Some of his experiments have already given him images with a distinctly coronal appearance, but he withholds an expression of opinion as to their reality until an opportunity occurs of comparing them with photographs taken simultaneously during a total solar eclipse or by a similar process at distant and elevated observatories.

Lunar Theory.

M. Radau has published during the year 1892 some important work on the inequalities of long period, suggested by the researches of Mr. G. W. Hill. He has succeeded in simplifying the computation of the inequalities due to planetary action, firstly by decomposing the disturbing function into a series of groups, and next by introducing systematically the expressions—

$$\Delta b_s^i = b_s^i - a\, b_s^{i-1}, \qquad \Delta^2 b_s^i = b_s^i - 2\, a\, b_s^{i-1} + a^2 b_s^{i-2}, \text{ \&c.,}$$

where b_s^i is a Laplace's coefficient. M. Radau has tabulated a list of arguments of long period which might be important, and has examined a large number of them, some of them giving rise to inequalities of several tenths of a second in amplitude. He has also shown that the arguments $(2w - 3y)$ and $(2w - 5L' + 3V)$, due to the action of *Jupiter* and *Venus* respec-

tively, each produce an inequality of long period, together with a sensible inequality of short period, just as in the case of the argument $(2w-2y)$ considered by Mr. Neison and Mr. Hill. Thus there are several inequalities to be taken into account in comparing Hansen's tables with observation.

Selenographical Notes.

The critical examination of the fine negatives of the Moon taken during the last two or three years with the 36-inch refractor of the Lick Observatory has tended to give a very decided impulse to selenography. Some of the more perfect examples of these productions have been submitted to Dr. L. Weinek, of Prague, who, with a great expenditure of skill and patience, has succeeded in producing enlargements of certain formations included in these photographs which have brought to light many unrecorded features. Beautiful photogravures of his faithful delineations of some of these enlargements have recently been published in a volume dealing with the astronomical observations made at the Royal Observatory at Prague during the years 1888–91, among which perhaps the most remarkable are those representing the great walled plains, Petavius and Vendelinus.

During the past year Prof. W. H. Pickering, at Arequipa, has devoted much attention to the observation of lunar detail with the large telescope in his charge. His observations relate mainly to the craterlets and minute light spots on the floor of Plato, and the bright streaks radiating from Tycho, Copernicus, and other formations. His Plato investigations go far to strengthen the suspicion that changes in the appearance and visibility of the spots have taken place during the last twenty years. As regards the bright streak systems, he contends that the various rays of which they are composed are not so long or continuous as has been hitherto believed, but that they rarely exceed fifty miles in length, and are often not more than ten miles long; while at the minute craters from which, as he maintains, they issue, they are not more than a quarter of a mile in width. He suggests that they may be due to the deposition of fine white dust or powder ejected from certain small craters that lie in the path of the rays, which is carried by wind currents caused by the condensation and absorption in surrounding regions of large quantities of gas or steam emanating from craters near the ray centres. His ingenious hypothesis appears to resemble in many respects that advanced many years ago by M. Chacornac.

During the past year certain craters and other details have been detected which are not recorded in Schmidt's large map of the Moon, many of them being visible in instruments of very moderate size under suitable conditions. Some of these objects were found on enlargements of the Lick Observatory negatives, and their existence subsequently confirmed by direct observation.

The discovery of others is mainly due to the systematic scrutiny of certain formations (Vendelinus, Ptolemaus, the surrounding region, &c.) by the Lunar Section of the British Astronomical Association. T. G. E.

M. Trouvelot's Observations of Venus.

An extensive and important series of observations of the planet *Venus* by M. Trouvelot has recently been published by the Société Astronomique de France. The observations appear to have been very carefully made and are very numerous, as many as 744 observations and 295 sketches of the planet having been obtained since the year 1876. The memoir is divided into 10 sections, the first of which relates to the visibility of *Venus* to the naked eye in full day. The planet is said to be thus visible in all parts of its orbit in the clear sky of Cambridge, U.S.A., when its angular distance from the Sun is not less than 10° near inferior, or 5° near superior conjunction.

Section III. deals with certain whitish and greyish spots. These nearly always appear in the neighbourhood of the terminator, and are generally of short duration. But a grey spot of a different character to the others was observed in 1876. It was characterised by its large size, its long duration, and by its comparatively well-defined and peculiar form. A marking of almost identical appearance was also frequently observed in 1891, and the author is inclined to believe that these two spots were really one, and that we have here a permanent spot usually concealed by an ordinarily opaque atmosphere, and only becoming visible when there is a temporary clearance in the atmospheric layers situated above it. A large number of observations of the spot of 1891 are given at length, and these indicate a curious circumstance. The spot appears to have arrived at the same position on the disc at a later and later time on each succeeding day. The author concludes that this peculiarity indicates a period of rotation slightly longer than that of the Earth.

Section V. is on the polar spots of *Venus*. These consist of brilliant white spots of a permanent nature, nearly always visible on the limb near the two horns, and never departing much from these positions. From their nearly invariable position the author considers that these spots mark the poles of rotation of the planet, and that they really consist of high mountain masses emerging beyond the dense atmosphere of the planet. Under favourable circumstances the margins of these polar spots have appeared formed of minute brilliant points or separate peaks. M. Trouvelot points out that these polar spots have been seen in some form or other by a large number of observers. From their positions, as given in a great many drawings, and from measures of their angle of position, he concludes that the equator of the planet is only inclined 10° or 12° to the plane of the orbit of *Venus*, and that the north polar spot is at a summer solstice

when the longitude of the planet is 92°. These elements differ largely from those generally stated, and it will be noticed that the old conclusions of Schroeter as to the existence of lofty mountains are revived in the present memoir. In fact, many of the phenomena noted by Schroeter are confirmed by the present series of observations.

The two succeeding sections deal with the terminator, horns, and phase. A great many observations and sketches are given, and it appears that the line of the terminator often departs from a regular curve, and that the horns undergo considerable variations. From observations of 9 elongations dichotomy occurred at east elongation 4 to 8 days before, and at west elongation 6 to 11 days after, the time of greatest elongation.

The question of the duration of the rotation of *Venus* is, perhaps, the one of most importance just at present. M. Trouvelot examines this question at some length, especially in connection with the observations of Professor Schiaparelli, and concludes that the motion of rotation is a rather rapid one, not differing much from 24 hours. A. S. W.

The Opposition of Mars.

The recent opposition of *Mars*, though one of the first order as regards the proximity of the planet, has not added much to our knowledge of its surface and physical condition. This has been partly due to the prevalence of bad observing weather near the time of opposition, but still more to the great southern declination of the planet, which rendered it very difficult for northern astronomers to observe with advantage.

The principal observations recorded are the following: The rapid decrease of the white cap round the south pole during the interval from the spring equinox to the summer solstice of the planet's Southern Hemisphere; the detection by M. Perrotin, and independently by Professor W. H. Pickering and other observers, of a number of bright white spots, other than the polar caps, and which appeared, when close to the limb, to project beyond it; the identification by several observers of some of Schiaparelli's "canals," the detection of some new ones, and the observation of the duplication of two or three—in one case, that of the *Ganges*, the phenomenon being independently recorded by several widely-separated observers; the suggestion of the discontinuity of the "canals," by Professor Young, apparently confirmed in one instance by a drawing by Mr. Walter Gale; and, lastly, the establishment of the fact that considerable changes have taken place in various regions of the planet, and more especially in the neighbourhood of Green's Terby Sea, the *Lacus Solis* of Schiaparelli's nomenclature. The published drawings, of which a large number have appeared in *L'Astronomie* and *Astronomy and Astro-Physics*, appear to emphasise three facts: (1) The stability of certain leading features

of the planet; (2) The great extent to which personal differences affect designs of this planet, perhaps the most difficult object in the heavens to sketch truthfully and satisfactorily; and (3) the occurrence of real changes in the appearance of the planet on a scale which it is difficult to reconcile with the usually accepted theory that the brighter and darker markings indicate respectively land and sea.

On this point Mr. Schæberle has argued that the ordinary interpretation should be reversed and that the brighter markings represent water. To this contention he will receive little assent. Professor W. H. Pickering, whose position at the lofty station of Arequipa, where *Mars* was nearly in the zenith, gave him special facilities for observation, regards only the very darkest of the dark regions as sea, and confines the water on the planet to the Kaiser Sea and Herschel Strait. Professor Pickering has also given great attention to the colour of the different districts of the planet, and has made several interesting observations in this direction. These claim a delicate discrimination of tint considerably in advance of anything previously secured, and, though observations made in a field where personality is so influential as colour perception must be received with some reserve until independently confirmed, the advantages Professor Pickering has enjoyed for this research are very great.

The Orbit of Iapetus and Mass of Saturn.

The mass of *Saturn*, deduced by Professor A. Hall from observations of *Iapetus*, made during the years 1875, 1876, and 1877, with the great Washington refractor, was $\frac{1}{3481}$, whilst that deduced by Mr. A. Hall, junr., from heliometer measures of *Titan* made at Yale in 1885–87 was $\frac{1}{3501}$, agreeing substantially with the results obtained by Bessel and H. Struve.

Under these circumstances Professor A. Hall undertook a fresh series of observations of *Iapetus* in 1889 and 1890, the results of which are published in the *Astronomical Journal*, No. 253. In 1889 the orbit plane of *Iapetus* had returned to a similar position to that which it occupied in 1875, except that the apparent motion of the satellite was reversed, and Professor Hall consequently followed his plan of 1875–77 in observing differences of right ascension and declination of *Saturn* and *Iapetus*; the determination of the mean distance of the satellite depending almost entirely on the former, as the differences of declination were very small.

Professor Hall decided to include all the observations obtained in his final solution of the equations, although there appeared to be a systematic difference between the measures

made with the filar micrometer and those obtained by means of the chronograph, which sensibly increase the probable errors of his results. The corrections to the previously-obtained values of the mean longitude and period are small, indicating that the assumed values are nearly correct, whilst the position of the perisaturnium is still somewhat uncertain. The correction to the assumed value of the mean distance, 515″·5195, is − 0″·2153 ± 0″·06387, and the corresponding value of the mass of *Saturn* is $\frac{1}{3485{\cdot}7 \pm 1{\cdot}28}$. A. M. W. D.

The System of Algol.

Argelander demonstrated the prevalence of cumulative inequalities in the period of Algol's light-change; but it was not until 1888 that their law was investigated by Dr. Chandler (*Astronomical Journal*, Nos. 165–7). Through the discussion of nearly 700 observed minima, he succeeded in resolving the inequalities they attested into two principal components—one with a period of about 141 years, and a coefficient of 173·3 minutes, the other with a period of 37·7 years, and a coefficient of eighteen minutes, upon which a third small variation in seventeen years appeared to be superposed. Early in the past year, he propounded a theory of a highly interesting character explanatory of the main part of these inequalities. They cannot be the immediate product of gravitational action, the distance implied by the length of period precluding the possibility of connecting effects so considerable with the presence of a perturbing body. They are accordingly ascribed to differences in the times of light-transmission from the various parts of a large orbit described by *Algol* and its close companion round an invisible primary. This orbit is sensibly circular, and lies in a plane inclined about 20° to our line of sight. It is traversed in 131 years, at a distance from the centre of gravity of the system of nineteen astronomical units, or just that of *Uranus* from the Sun, and light crosses its foreshortened radius in 149 minutes. To this extent, then, the eclipses of *Algol* seem alternately accelerated and delayed, as the star approaches towards, and retires from, the Earth. A retardation, amounting in 1843 to 165 minutes, shows, however, that the theory does not completely cover the facts, and Dr. Chandler fully admits the concurrence of further disturbances, the explanation of which will demand prolonged researches. Its fundamental assumptions are, indeed, capable of easy verification. The star is timed to reach the nearest point of its orbit to ourselves within six or seven years, when a maximum of acceleration should occur, after which the intervals between each eclipse should begin steadily to lengthen, until, at the passage of the ascending node, about 1934, coincidence of their observed and mean epochs should come to pass, to be again followed by a lagging of the

former. The velocity of *Algol* in its hypothetical wide orbit is two and a half miles a second, of which less than half is at present directed towards the Earth.

Dr. Chandler's inferences do not rest wholly upon fluctuations in this star's period of variability. He derives confirmation to his theory from meridian observations of it since 1753. They seem to show an undulatory mode of progression, due possibly, as he supposes, to the description of a projected ellipse with a major axis of 2″·7. It is, nevertheless, far too soon to pronounce upon the true character of deviations from rectilinear motion, which, although they appear to proceed regularly, both in right ascension and declination, may turn out to be purely accidental. Their reality is, however, countenanced by the identity of the parallax which they imply for *Algol* of 0″·07, corresponding to a light-journey of nearly forty-seven years, with that photographically determined by Professor Pritchard. The emissive power of a star so curiously associated with two obscure masses would, at that distance, be equal to that of *Sirius*. Dr. Chandler does not despair of the actual telescopic discovery of the primary body, if even slightly luminous. Its position-angle relative to *Algol* is just now 32°; its distance, assuming the correctness of Vogel's elements for the close couple, should be 2″. But even if it have an objective existence, it may be doubted whether it will ever be seen. A. M. C.

Sirius and its Companion.

The Companion of *Sirius*, having traversed nearly 90° of its relative orbit since its optical discovery by Alvan Clark in 1862, has now approached its primary so closely that it will be impossible to obtain any measures of its position for at least two or three years from the present time. Professor Auwers has accordingly taken this opportunity to continue his researches on the motions of the *Sirius* system, and has published his results in *Astronomische Nachrichten*, Nos. 3084–85.

Starting from the elements of the orbit of *Sirius* with respect to the centre of gravity of the system, deduced from meridian observations which he published many years ago in *Publicationen der Astronomischen Gesellschaft*, No. vii., Professor Auwers has compared the measures of the relative position of the Companion, made since its discovery, with an ephemeris computed from the above-mentioned elements on the assumption that the ratio of the mass of *Sirius* to that of its Companion is 2·05 : 1, and, therefore, that the mean distance in the relative orbit is $a\,(1+2{\cdot}05) = 7''{\cdot}109$; a being the mean distance in the orbit described by *Sirius* relative to the centre of gravity. From the residuals thus obtained Professor Auwers computes corrections to the assumed elements, with the exception of the period which of course cannot be satisfactorily determined from observations

extending over 90° of anomaly only. From a comparison of the individual observations with the places computed from the resulting elements Professor Auwers determines the "personal equations" of the several observers who took part in the measures, and, introducing the values thus obtained into the equations of condition, proceeds to a second approximation. The elements determined (1) from meridian observations of *Sirius* (with the above-mentioned assumption as to the ratio of the masses), and (2) from measures of the relative position-angle and distance of the Companion with respect to *Sirius* are as follows:—

	(1.)	(2.)
T	1843·275	1844·216
U	49·399 years	49·399 years
n	−7°·2877	−7·2877
$a(1+m)$	7″·109	7″·568
e	0·6148	0·6292
i	47° 8′·7	42° 25′·6
Ω	61° 57′·8 (1850)	37° 30′·7 (1850)
$\pi-\Omega$	18° 54′·5	39° 56′·5

A comparison of the meridian observations of *Sirius* from which the elements (1) were obtained (extending from 1750 to 1864), with places computed from the elements (2), but with the original value of a—*i.e.* 2″·3307—gives for correction to a from observations of right ascension +0″·2708, and from observations of declination −0″·2958. Adopting a weighted mean correction +0″·0910, the corresponding value of a is 2″·4217, and, adopting the value of a $(1+m)$ from orbit (2), the corresponding ratio of the masses is 2·125 : 1. Assuming Gill and Elkin's value of the parallax of *Sirius*, 0″·38, it follows that

Mass of bright star = 2·21 × mass of Sun.
Mass of companion = 1·04 × mass of Sun.

Professor Auwers includes two useful ephemerides in his paper, one giving the relative position-angle and distance of the Companion referred to the Primary Star, and the other giving the differences of right ascension and declination of the bright star referred to the centre of gravity of the system. The researches embodied in this paper place beyond reasonable doubt the identity of the Alvan Clark Companion with the body which causes the observed irregularities in the motion (transverse to the line of sight) of the bright star; and, notwithstanding the uncertainty in the value of a, arising from discordance in the results deduced from the right ascensions and from the declinations, supply us with the means of computing the relative positions of the components of the *Sirius* system with (in all probability) considerable accuracy for, at least, several years to come. A. M. W. D.

Measures of Rutherfurd's Star Photographs.

On 1890 November 13, our late Associate Lewis M. Rutherfurd, presented to the Columbia College Observatory his complete set of original negatives (wet plates) of the Sun, the Moon, and many star clusters; also some thirty quarto volumes of measures of certain star plates. A catalogue of the plates was published in the *Annals of the New York Academy of Sciences*, vi., 1891 June.

Mr. Harold Jacoby, of the Columbia College Observatory, immediately set about the reduction of the star measures, beginning with the latest plates of the *Pleiades*; and two memoirs, one on the *Pleiades* group, and another on the stars about *β Cygni*, have appeared within the last year. The first memoir, of 70 pp., 8vo. contains the measures of photographs in 1872 and 1874, the *Pleiades* being selected for measurement first, "because the group offers the best opportunity for judging of the accuracy obtainable by the methods employed." The result is eminently satisfactory, as appears from comparison of the places deduced with those found by the Yale and Königsberg heliometers; and it is concluded, with good reason, that the "present photographic observations are entitled to be taken into consideration if it be desired to make a study of proper motions, or to form a definitive catalogue of the *Pleiades*." We may, perhaps, add that remeasurement of these plates now would afford valuable evidence as to the stability of a photographic film for nearly twenty years, and would be of considerable importance in view of modern photographic undertakings.

The general accuracy of the method being thus established, several precautions adopted in the first memoir have been omitted in the second, much labour and detail in printing being thereby saved. It may be explained that in making the exposures two impressions were taken on each plate. The second impression is west of the first. After it was finished the clockwork of the telescope was stopped, and the cluster allowed to move off the plate, the brighter stars leaving "trails." Shortly before the star reached the edge of the plate, the clock was again started, and the central star was allowed to impress itself once more, thus giving the orientation. For the *Pleiades* both the eastern and western impressions were always measured, and in the reductions these sets of measures have been treated as if they came from separate plates; but the results were satisfactorily accordant, and therefore, for the *β Cygni* cluster, the measures of the eastern and western impressions were not separately reduced.

The distances were referred to a glass scale, which was carefully calibrated. Convenient formulæ and tables are given in the paper for the refraction correction. The final result is a catalogue of seventy-five stars of the *Pleiades*, and forty-two of the *β Cygni* cluster.

Double Stars.

This branch of astronomy is divided into three distinct sections, discovery, micrometric measures, and, finally, discussion of the observations. It rarely happens that all three sections are taken up by one man, and the retirement of such an individual leaves a serious gap. It falls within the province of the Royal Astronomical Society to call attention to the importance of continuing the micrometric work of Mr. Burnham.

Two Burnham catalogues of new doubles have appeared during the year 1892, and practically all were discovered with the 36-inch refractor while some other pair was being examined. No systematic search was made, and yet altogether Mr. Burnham's contributions now reach the number 1,274; many of which pairs have already become well known, and many more give promise of becoming interesting systems. His measures of double stars are almost entirely confined to the more difficult and most interesting binaries, and here his retirement will be most felt. A perusal of the measures of distance tends to show that the measurement of $0''{\cdot}1$ was a simple matter with the large refractor.

Professor Hall has published his measures during the years 1880–1891, in continuation of the work begun 16 years since with the 26-inch Washington refractor, and they form a valuable series of measures of close doubles, and also of wider pairs to connect his work with that of other observers.

Other measures by Maw, Seabroke, Glasenapp, Russell, and Tebbutt have been recently published. T. L.

Potsdam Observations of Motions of Stars in the Line of Sight.

Professor H. C. Vogel has published during the year in the seventh volume of the *Potsdam Observations*, Part I., the details of his spectrographic determination of the motions of fifty-one stars in the line of sight. Reference to this work will be found in the President's Address on presenting the Gold Medal of the Society to Professor Vogel for his astronomical work, and especially for this particular research.

Drawings of the Milky Way.

During the past year the Earl of Rosse has published reproductions of the drawing of the Milky Way made with the naked eye at Birr Castle Observatory by Dr. Otto Boeddicker, during the years 1884–89. The original drawings were exhibited at the meeting of the Society in 1889 November, and a note which accompanied them (*Monthly Notices*, vol. l. p. 12) describes the methods of observation and the means taken to ensure accuracy

in delineation. Dr. Boeddicker's work may be considered almost the only detailed representation of the northern portion of the Galaxy, since most previous drawings are either slight indications of the more prominent features, or, like that of Houzeau and the much more elaborate drawing of Heis, are mainly intended to show the relative intensity of different areas. The drawing executed in 1874–76 by M. Trouvelot fairly represents the naked-eye appearance of the Milky Way, but in far less detail than Dr. Boeddicker's, in which the complexity of structure is very remarkable. It will be important to see if all the features he delineates are confirmed by other observers, but many of these details have already been observed by Gore, Backhouse, and others.

Dr. Boeddicker's drawing extends to about 10° south declination; the stars have been taken from Argelander's *Uranometria Nova*, but the projection on which they are drawn involves considerable exaggeration in the scale. The plan suggested by Mr. Marth would avoid this disadvantage.

The Discussion of the "Draper Catalogue."

Professor E. C. Pickering has followed the publication of the great "Draper Catalogue of Stellar Spectra" (vol. xxvii. of the *Annals of the Astronomical Observatory of Harvard College*) by a companion volume (vol. xxvii. Part I.), in which he describes at length the methods of work employed in the formation of the catalogue, together with such additional details respecting the photographs as could not be conveniently included in the former volume. This includes, therefore, not only a full description of the Bache telescope, and the mode of its employment and of the reduction of the photographs, but also a catalogue of the 3,300 plates taken with that instrument, many of which were experimental. Following this additional information, Professor Pickering discusses in the five following chapters several points arising out of the catalogue itself. The attempt made to determine the "photographic magnitudes" of the stars observed, by comparing the intensity of the photographic images for one particular wave-length—a very important novelty in the "Draper Catalogue"—gave rise to some special difficulties, since in many stars, especially those of Secchi's second type, the photographic intensity changes at the very point of the spectrum chosen as the standard wave-length. The third-type stars were measured at four or five points, since these spectra show several regions where the intensity changes suddenly. The details of these measures, and also the measures of those stars whose photographic magnitude was redetermined on account of discordances found in the original catalogue, form an important feature of the volume.

A revision of his results leads Professor Pickering to somewhat simplify the system of classification adopted in the "Draper Catalogue." Spectra E and G are grouped together,

as are also H, I, and K, the apparent differences lying probably in the intensity of the photographic image rather than in the stars themselves, so that he almost returns to Secchi's four types, still distinguishing, however, between the two classes of spectra of the solar type, of which *Arcturus* and *Capella* may be taken as examples.

A point of great importance brought out in the present volume is the predominance of first-type stars in the Milky Way. "The Milky Way," Professor Pickering concludes, "must, therefore, be described as a distinct cluster of stars to which, from its age or composition, the Sun does not belong." But stars with types of spectra which are usually regarded as very distinct from the Sirian also exhibit a most marked preference for the Galaxy, bright line stars of the Wolf-Rayet type being strictly galactic. No fewer than nineteen of these were discovered on the examination of the photographs, all being situated within the Galaxy and close to its equator. The tendency of *Novæ* to appear within the Milky Way, or at least on some of its branches, is well known. A curious fact with regard to eye-estimates of stars in the Milky Way is also noticed by Professor Pickering—viz. that the magnitudes thus determined are too faint by about 0·2; an effect which appears to be nearly independent of the magnitude of the star, and practically independent of its spectrum. The last chapter gives a comparison between the visual spectroscopic catalogues of Vogel and Konkoly and the "Draper Catalogue," from which it appears that stars of Pickering's types F and G in the great majority of instances gave spectra which to the eye appear of the Sirian character. As a rule, the photographs lend no support to the idea of variation of stellar spectra, except in the cases of the "spectroscopic doubles" and of certain variables. But in some instances of stars of the second type there appears to be some evidence of a change in the relative intensity of the spectrum above and below G, due to an actual spectral change, and not to the special photographic conditions.

Mountain Observatories.

In 1887 Mr. Boyden bequeathed a considerable sum of money to aid in the establishment of an observatory "at such an elevation as to be free, so far as is practicable, from the impediments to accurate observations which occur in the observatories now existing, owing to atmospheric influences." In 1888, observations were taken at three stations in Colorado, namely, Colorado Springs, Seven Lakes, and Pike's Peak, and at the first-named locality the shortest wave-length yet photographed in any celestial spectrum was obtained. The experiments also showed that, after a certain height, increase of altitude ceases to be of advantage, and a more important factor is the dryness of the atmosphere.

In 1889 and 1890, experimental observations were made in

Peru, and it was decided to erect the observatory at Arequipa, at an elevation of 8,055 feet. The latitude and longitude are, roughly, 16°·24′ S. and $4^h\ 45^m\ 30^s$ W. of Greenwich. The meteorological conditions are exceptionally good; the atmosphere is very dry and clear, except during the months of November, January, and February, when the rainfall amounts to 2 or 3 inches. Throughout the year the variation of the barometer does not exceed 0·2 inches. Earthquakes are frequent and sometimes severe, and to minimise their evil effects the pier of the telescope is buried deep in solid stone masonry, and the dome is made of as light materials as possible. The instruments in use are: a 5-inch visual telescope, intended for solar work; an 8-inch Bache, with which some 1,300 photographs have been taken during the past year; a 2½-inch camera of very short focus, with which the great outer spiral of the *Orion* nebula was discovered during the observations in California, and also later in Peru, the similar spiral structure of the Greater Magellanic cloud. There is also a 20-inch reflector of 45 inches focus, made by Dr. Common for the solar eclipse of 1889, and intended for the study of faint nebular detail; and a 13-inch refractor by Clark, which can be used either for visual observation, or, by reversing the crown lens and shifting the flint, can be converted into a photographic telescope.

Three new observatories, at considerable elevations, are in course of construction. A meteorological station, built at Meudon under the superintendence of M. Janssen and M. Eiffel, is in process of being conveyed to the top of Mont Blanc. The new observatory will be pyramidal in shape, and to secure as much stability as possible, two-thirds of the structure will be buried in the snow. M. Janssen has taken observations during the past year in a small temporary building, with a view to testing the stability of the snow as a foundation, and has judged the results quite satisfactory.

M. Bischoffsheim and M. Perrotin propose to erect an observatory on Mount Monnier, in the Maritime Alps, at a height of 2,800 metres. Observations will begin in 1893 April.

The Grand Duke George Mikhaïlowitch has founded an astronomical observatory at Abastouman, in Tiflis, in lat. 41°·46′ N. and long. 40°·32′ E. of Paris. M. Glasenapp has already conveyed there a 9-inch refractor, and many measures of double stars have been made in the last few months. The height of the observatory above the sea-level is 4,600 feet. A. S. D. R.

Strassmaier and Epping's Researches on Babylonian Astronomy.

Among the cuneiform astronomical texts which have been deciphered and explained by the joint labours of Fathers Strassmaier and Epping, there are two recently published (*Zeitschrift für Assyriologie*, 1892, pp. 220 *et seq.*) which are of very great importance. For they contain the astronomical journals

of the Babylonian observers during portions of the years 38 and 79 of the Seleucidæan era. The first embraces the period from 274 B.C. October 6 to 273 B.C. March 2, and the second that included between the dates 233 B.C. October 3 and 232 B.C. March 28. The paper in which the texts are discussed is divided into six sections. Of these the first four are occupied with the setting forth and explanation of some technical terms which occur in the astronomical nomenclature of the Babylonians, the knowledge of which is a necessary preliminary for the deciphering and full understanding of the meaning of their observations. These sections may therefore be considered as part of the very thorough discussion of the Babylonian methods of prediction and observation, and of their manner of stating the same, which has been conducted by the authors during the last eleven years. In the first section of the present paper those expressions are determined which refer to the progression and retrogression of the planets, in the second those which were employed in relation to conjunctions of the Moon and planets. For instance, one symbolical expression denoted that at the time of observation a conjunction had not yet taken place, but was imminent; another that the conjunction had occurred shortly before the recorded observation. The third section gives in tabular form the Babylonian names and symbols for the signs of the Zodiac; the fourth contains the same data for 34 normal stars, which were employed in these planetary observations according to a method already described. The stars identified in the present table are *η Piscium*; *α, β Arietis*; *η Pleiadum*; *α, β, ζ Tauri*; *α, β, γ, η, μ Geminorum*; *δ, γ, ε, θ Cancri*; *α, β, ε, θ, ρ Leonis*; *α, β, γ Virginis*; *α, β Libræ*; *α, β, δ Scorpionis*; *θ Ophiuchi*; *α, β, γ, δ Capricorni*. The remaining sections of the paper contain the observations, the transliteration of the Babylonian texts, and the corresponding translation being placed in parallel columns. We give a specimen taken from the beginning of the older of the two journals. Words in brackets are either explanatory notes, or indicate readings supplied by the authors to fill up lacunæ in the texts themselves:—

"The year 38 of Antiochus and Seleukhus the kings. Tishri 30 (*i.e.* the preceding month Elul had but twenty-nine days, and the 30th is Tishri 1st). The Moon's crescent, visible during the period of 15 time-degrees (1°=4 minutes). (On the 3rd = October 8, the Moon eastward) of *θ Ophiuchi*, one degree distant, above *Venus* distant 5 degrees . . . not seen together; the night of the 5th (= October 10) at the beginning of the night the Moon westward from *Mars*, distant 1½ degrees; the Moon 2½ degrees higher towards the north; on the 5th, clouds, the heavens (dark?); on the 7th, clouds dark. (On the 8th) the Moon eastward of *δ Capricorni*, distant 1½ degrees; on the 8th, clouds, dark; the Sun (in a halo? Equator?); on the 9th, clouds, dark; on the night of the 10th (= October 15), at the beginning of the night, the Moon eastward of *Saturn*

1½ degrees distant, observed earlier (*i.e.* at the time of observation conjunction had not taken place, but was imminent), clouds, dark; the Moon (moving towards the North?). On the night of the 13th, at the beginning of the night, the Moon beneath *η Piscium*, distant 2½ degrees; the Moon half a degree backwards (*i.e.* not actually in conjunction with the star, but half a degree to the westward)."

Interspersed among the astronomical observations are remarks appertaining to religious, social, and commercial matters, as, for instance, there is mention made of the sacrifice offered to Bel on the feast of the new Moon by the General, "the second after the king in the land of Accad," of the price of wheat and of other grains, as also of the regulation of the tariff of Babylon, according to the Grecian rate of exchange, and of the movements of the king and his body-guard. The colophon appended to the first of these two diaries reads as follows: "Observations for the feast of the New Moon from the month of Tishri of the year 37 to the end of Adar, of the year 37 of Antiochus and Seleukhus, the Kings. Not revised, not revised." That which closes the second is: "Observations for the feast of the New Moon from Tishri to the end of Adar, in the year 79 of Seleukhus, the King." To each of these journals Father Epping has added a table, which contains the reduction of the observations to the ecliptic for the year A.D. 1800, the latitude and the longitude, and in some cases the elongation from the Sun, and the angle for determining the stationary point being given for Babylonian midnight of the respective days of observation. These two important tables furnish no less than ninety-five positions of the Moon, nine of *Mercury*, twelve of *Venus*, four of *Mars*, seven of *Jupiter*, and six of *Saturn*; while there are in addition thirty-one positions distributed among twenty-three of the normal stars. We thus have astronomical observations taken more than twenty-one centuries ago, not only deciphered and explained, but reduced and presented in modern tabular form. In order that the calculations should exactly correspond to the requirements of the texts, constant collation of the one with the other and revision of the latter are necessary, thus involving a very great amount of most patient labour. But the results so far achieved by the learned authors would seem to be of the highest value, not only for the history of astronomy, but also for the detection of secular variations in the movements of the Moon and planets. We may add that Father Strassmaier has deciphered many more texts, which are at present in the hands of Father Epping, that the necessary calculations may be effected. A. L. C.

Variation of Latitude.

In the Report of the Council in 1891 February, attention was called to a suspected variation in the latitude of certain places where accurate observations for latitude had been undertaken.

The question was then neither new nor old. The stability of latitude had certainly been questioned, but no systematic change, either secular or periodic, had been established. Since that time a complete change of ideas has been effected. There seems to be now distinct evidence of periodic changes in latitude, and more particularly of a rotation of the geographical round the astronomical pole in 427 days. The novelty of this hypothesis can hardly be denied. It cannot be relegated to the class of inequalities in zenith distance observations of period about a year, whose origin may be traced to temperature effects of a hundred different classes; although it will presently appear that something new has to be said even on the subject of these annual terms.

And although the merit of having stimulated the special observations and investigations which have led to the unlocking of this secret chamber, must be shared by several people, Mr. S. C. Chandler is undoubtedly to be credited with the actual finding of the key.

He was also one of the earliest to initiate the search (if we except M. Nobile, who for many years pointed out the existence of systematic errors which might be changes of latitude, without attaining to a clear demonstration of any regular law). His observations with the almucantar at Cambridge, U.S., from 1884 June to 1885 June, first suggested to him, not only the possibility of a variation in latitude, but the law of the variation. Twelve months' observations were of course not sufficient to establish a periodicity of fourteen months, though they might suggest it; and Mr. Chandler was plainly somewhat lucky in being so near the truth with his first guess. But this good fortune he supplemented by proper reserve in stating any deduction from these early observations, and by equal promptitude in following up his own line of thought when independent observations offered confirmation. This confirmation was due to Dr. Küstner, who, in his determination of the aberration from a series of observations coincident in time with those of the almucantar, came upon similar anomalies; and whose results, published in 1888, furnished a counterpart to those pointed out by Mr. Chandler in 1885.

Further evidence bearing on the question was forthcoming in the parallel determinations at Berlin, Prague, Potsdam, and Pulkowa, which showed changes in apparent latitude, not only strikingly sympathetic among themselves, but of the same range and periodicity as those noticed in 1885; and Mr. Chandler "was led to make further investigations on the subjects, which seem to establish the nature of the law of these changes, and proceeded (1891 November) to present them in due order."

The consequent series of papers in the *Astronomical Journal* can hardly fail to take its place as one of the astronomical classics. The following summary is made purposely very brief because the series is not yet complete, and no doubt much still

remains to be said on such an important subject. But it will be seen that during the year 1892 (including perhaps the end of 1891) a most important advance has been made in fundamental astronomy.

The first paper (regarding that already mentioned as preliminary) deals with the observations with the Pulkowa vertical circle (1863–1875), "which have been provocative of so much inquiry, so far without any solution of the anomalies which they show in regard to this question of latitude variation," and the Washington prime-vertical observations (1862–1867), "the most accurate determinations of declination ever made at the Naval Observatory" which yet "resulted in anomalous values of the aberration constant in the different years and a negative parallax in all." Mr. Chandler finds that a 427-day period in the latitude "furnishes the true key to the troublesome discordances in the Pulkowa latitudes," and "traces to their origin the anomalies in the Washington observations." Further, the comparison of the two series leads to the same conclusion as that already shown from the simultaneous series at Berlin and Cambridge (U.S.) in 1885 as to the *direction* of the polar motion. In the next paper it is mentioned that observations at Melbourne (1863–1884) and Leyden (1863–1867) are in complete accordance with those made at the same time at Pulkowa and Washington; and that the 427-day period accounts for the contradictory results obtained by Dr. Van Hennekeler at Leyden. The motion of the Earth's pole for the period 1860–1870 is thus fairly established. The author proceeds to consider earlier observations. In the papers numbered 3 and 4, the systematic errors of Bradley's observations, which were reduced afresh for this purpose, are discussed, particularly the collimation error. It is then concluded that the observations indicate a rotation of the pole in little more than a year and with a larger radius than that of 1860-1880, the range being about 1″. In the same paper Mr. Chandler states that Brinkley's observations at Dublin (1808–1813 and 1818–1822) are found to indicate a rotation in about a year, with range more than 1″, "wherein lies the solution of the hitherto unsolved enigma of Brinkley's singular results which led to the spirited and almost acrimonious dispute between Brinkley and Pond with regard to stellar parallaxes." The details were promised in a later paper, but have not yet been given, owing doubtless to the necessity of attending to a vitally important point which will presently appear.

In Papers V. and VI. are presented the results of an enormous mass of reductions, extending from 1837–1891, made at no fewer than seventeen observatories. The whole is broken up into forty-five series, or short groups, for the purposes of this particular discussion; and the result of this minute inquiry, confirmed (or perhaps suggested) by the observations of Bradley and Brinkley above-mentioned, seemed clear, viz., that the "instantaneous rate of angular motion of the pole has been

diminishing during the last half-century, at a sensibly uniform rate, by its one-hundred-thousandth part."

The remarkable manner in which Mr. Chandler was led to modify this statement within a few weeks is worthy of far more detailed treatment than space will here allow.

Astronomers had hesitated to accept the 427-day period, even in face of the very strong evidence of the 1860–1880 observations, owing to the difficulty in accounting for it theoretically. It had been pointed out by Euler that, treating the Earth as a rigid body, the period of rotation of the pole must be 306 days. Professor Newcomb, however, happily pointed out that a qualified rigidity (either actual viscosity or the composite character due to the ocean) afforded an explanation of this longer period; and after this suggestion Mr. Chandler's 427-day period was well and even warmly received. But the further elaboration of this hypothesis by a changing period was a new difficulty.

Professor Newcomb himself, who had reconciled the first article of the hypothesis with theory, was not slow to declare that the second was irreconcilable. Mr. Chandler's reply, in Paper VI., is a model of controversial courtesy and skill, but we can only quote a few sentences:—"It should first be said that in beginning these investigations I deliberately put aside all teachings of theory, because it seemed to me high time that the facts should be examined by a purely inductive process; that the nugatory results of all attempts to detect the existence of the Eulerian period probably arose from a defect of the theory itself; and that the entangled condition of the whole subject required that it should be examined afresh by processes unfettered by any preconceived notions whatever. . . . The appeal to observation, treated irrespective of theory, in the present series of papers, shows that a rotation of the pole really exists, but (*a*) at a daily rate of but 0°·85 (for 1875), and (*b*) that this velocity is subject to a slow retardation, which, in its turn, is not uniform. . . . The result (*a*) was at first pronounced impossible, and is even now so regarded in some quarters. Professor Newcomb, however, soon after found the defect in the theory, and is now as cordially in favour of the result given by observation as he was originally against it. . . . Now, may it not reasonably be asked if the direct deduction from observation has led to the correction of theory in the first particular, is it beyond hope that it may do so in regard to the second?"

Such a truly scientific attitude inspires confidence that the search is being rightly conducted; but the most sanguine could hardly be prepared for the reconciliation of observation and theory in the very next paper of the series, published six weeks later. By this time Mr. Chandler has rearranged his material and found, not *one variable* rotation of the pole, but *two constant* rotations (with a qualification), one in 427 days, and the other in about a year. The qualification is that the *amplitude* of the latter is apparently variable, not the period. The superposition

of these two rotations is almost exactly equivalent, for the observations available, to the law (or summary of observation as it might fairly be called) previously enounced. To make clear the novelty of this discovery it may be remarked that, although fluctuations in zenith distances of annual period have long been recognised, they have generally been ascribed to temperature effects, in which case the maxima and minima for all stations in the Northern Hemisphere should occur at the same epoch—say midsummer and midwinter. But this is not the case with the annual term now revealed. The epoch changes with the longitude, showing that the pole moves just as in the case of the 427-day term.

It is somewhat remarkable that two formulæ, differing so much in form, should be found to represent the observations almost equally well. Apparently this is to be attributed chiefly to the variability in amplitude of the annual term, and as yet this variability has not been accounted for. But to have advanced the work to this stage in such a short time is a great achievement, and much may confidently be expected from Mr. Chandler's future work. He points out, in a paper dated 1893 January 2, that the discovery of these periodic inequalities in the latitude makes it necessary to go over much old work afresh, and is himself leading the way with a discussion of the aberration constant.

In the same paper he shows that the recent results obtained at Berlin, Prague, Strassburg, Pulkowa, Rockville, and Honolulu, give a mean correction to his final formula of only five days in the epoch; "and the accordance of the separate values is high testimony to the skill of the observers, to whom astronomers owe a deep debt of gratitude for their laborious and conscientious work."

The Photographic Chart of the Heavens.

During the year 1892 the actual work of forming a chart has practically been commenced at several observatories. The adverse report of the sub-committee on gauze screens led to the settlement, or rather the evasion of a definite settlement, of the vexed question of the time of exposure necessary to obtain stars of the 14th magnitude; and partly in consequence of this, partly because of other difficulties, plates of long exposure have not been taken at most observatories. But of those proper for the formation of a Catalogue, with exposures of 6^m, 3^m, and 20^s (the last supplementary exposure being proposed by the Astronomer Royal), many have been taken, and it may be hoped that the sky will soon have been covered by plates of this character. It is possible, therefore, that the history of this work may be for some years uneventful.

The first fascicule of Vol. ii. of the *Bulletin* appeared in 1892,

but the more important of its contents had already been published in anticipation, and were mentioned in the last report (*Monthly Notices*, lii. p. 292). An extract from the second fascicule has been circulated in advance by Professor Kapteyn, in which he shows, from the results obtained in the formation of the *Cape Durchmusterung*, that the light of stars near the Milky Way is richer in actinic rays than that of stars visually as bright in high galactic latitudes. His numerical result is that the excess of the photographic over the visual magnitude is found to increase 0·01 of a magnitude with each degree of galactic latitude. In a preface Dr. Gill explains that the photographs were not taken in a manner specially suited to the deduction of this important result, and that the research will be continued. This preliminary note is intended to put observers on their guard against assumptions of uniformity in the relation between photographic and visual magnitudes in different parts of the sky.

M. Trépied has published a review (of 50 pp. quarto) of the resolutions hitherto adopted by the Conference of 1887 and the subsequent committees, which will be of great value as a work of reference.

The death of Admiral Mouchez, whose energy and ability effected so much in connection with this undertaking, cannot fail to be seriously felt. He was far from seeing the completion of the great work he initiated, but it is some satisfaction to think that he lived to see the early difficulties overcome and the operations fairly commenced. The reputation of his successor at the observatory (M. Tisserand), and his expressed determination to take up this part of Admiral Mouchez's work, are matters for congratulation.

Though not directly connected with the Chart, it may be mentioned that Dr. Scheiner has measured two plates, taken with the Potsdam instrument, of the cluster in *Hercules* (13 M.), exposures 2^h and 1^h respectively, and has thus obtained the co-ordinates of 823 stars of the 12th to 14th magnitudes, the measures being closely accordant. The results (published in the *Abhand. der Kön. Preuss. Akad. der Wiss.*, Berlin 1892) bear striking testimony to the accuracy and value of the photographic method, in the particular form adopted for the Astrophotographic Chart.

Papers read before the Society from February 1892 to January 1893.

1892.

Mar. 11. Ephemeris of the satellites of *Uranus*, 1892. A. Marth.
The reappearance of *Saturn's* ring. G. Comstock.
Results of double star measures with the 8-inch equatoreal at Windsor. New South Wales, in 1891. J. Tebbutt.
Maxima and minima of variable stars, observed during the years 1889, 1890, and 1891. J. Mitchell.
On the displacement of the apparent radiant points of meteor showers, due to the attraction, rotation, and orbital motion of the earth. J. Kleiber.
Observations of nebulæ with the 36-inch refractor of the Lick Observatory. S. W. Burnham.
A new binary star, β 581. S. W. Burnham.
Occultation of γ_1 and γ_2 *Virginis*. Rev. A. Freeman.
The apparent places of close polar stars. A. M. W. Downing.
The new star in *Auriga*. G. Knott.
Photograph of the region of *Nova Cygni*. Isaac Roberts.
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On the photographic magnitude of *Nova Aurigæ*, as determined at the Royal Observatory, Greenwich. W. H. M. Christie.
On the large Sun-spot of 1892 February 5–17, and the associated magnetic disturbance, observed at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On an annual variation in the R – D discordance. H. H. Turner.

Observations of the spots and markings on the planet *Jupiter*, made at the Dearborn Observatory, Evanston, Illinois. Professor G. W. Hough.

Apr. 8. Note on the transit of *Titan*, 1892 March 11. A. Mee.

The double star Σ 3123. S. W. Burnham.

Anderson's new star in *Auriga*. S. W. Burnham.

Observations of the reappearance of the rings of *Saturn*: observations of the position-angles of the rings and observations of the satellites. E. E. Barnard.

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Note on the lunar theory. Professor E. W. Brown.

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Note on the spectrum of the great spot group of 1892 February. Professor K. D. Naegamvala.

On the estimation of star magnitudes by extinction with the wedge. Captain W. de W. Abney.

May. 13. Note on the secular perturbations of the Earth by *Mars*. R. T. A. Innes.

Note on the orbit of α *Centauri*. E. B. Powell.

On the orbit of γ *Centauri*. J. E. Gore.

Comet Swift, 1892 March. H. C. Russell.

On the orbit of γ *Coronæ Australis*. J. E. Gore.

Negatives of *Jupiter* made with the great telescope of the Lick Observatory during 1891. Professor E. S. Holden and W. W. Campbell.

On the illumination of *Saturn's* rings during sunrise, and on recent observations of their reappearance. Rev. A. Freeman.

Photographs of the region of the Crab Nebula, M 1 *Tauri*. Isaac Roberts.

Photographic search for a planet beyond the orbit of *Neptune*. Isaac Roberts.

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Ephemeris for physical observations of *Jupiter*, 1892 (continued). A. Marth.

On a new form of altazimuth. W. H. M. Christie.

Observations of the Moon made at the Radcliffe Observatory, Oxford, during the year 1891, and a comparison of the results with the tabular places from Hansen's Lunar Tables. E. J. Stone.

Observations of occultations of stars by the eclipsed

Moon on 1892 May 11, made at the Radcliffe Observatory, Oxford. Communicated by E. J. Stone.

Spectrum of *Nova Aurigæ*. Rev. W. Sidgreaves.

Partial eclipse of the Moon, 1892 May 11, observed at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Observations of Swift's comet (*a* 1892) made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Estimations of the magnitude of *Nova Aurigæ*. J. G. Lohse.

On a diagram useful as a guide in adjusting a diffraction grating spectroscope. H. F. Newall.

Comparison of magnitudes of *Nova Aurigæ* and neighbouring stars, made with the Newall telescope at the Observatory, Cambridge. H. F. Newall.

On a pretended early discovery of a satellite of *Mars*. Dr. R. Copeland.

June 10. Ephemeris of the satellites of *Mars*, 1892. A. Marth.

The lunar eclipse, 1892 May 11; observations made at Mr. Crossley's Observatory, Bermerside, Halifax. E. Crossley and J. Gledhill.

On a parallel plate double image micrometer. J. H. Poynting.

Occultations and other phenomena of the lunar eclipse, 1892 May 11. Rev. A. Freeman.

Orbit of 9 *Argûs*, β 101. Professor S. Glasenapp.

List of the proper motions in the line of sight of 51 stars. Professor H. C. Vogel.

The orbit of O Σ 269. J. E. Gore.

Observations of Wolf's periodical comet made at the Cambridge Observatory with the Northumberland equatoreal and square bar micrometer. Communicated by the Secretaries.

Photograph of the region of the globular cluster 15 M *Pegasi*. Isaac Roberts.

Photograph of the nebula H$\frac{I}{II}$ V. 15, near 52 *Cygni*. Isaac Roberts.

Observations of Comet *a* 1892 (Swift), made at the Royal Observatory, Cape of Good Hope. Communicated by David Gill.

Observations of Swift's Comet (*a* 1892), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Occultation of 73 *Piscium* by *Jupiter*, 1892 May 23, observed at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

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Note on Damoiseau's *Tables écliptiques des satellites de Jupiter*. A. M. W. Downing.

Photograph of *η Argûs*. H. C. Russell.

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Nov. 11. Note on the conjunction of *Venus* and *Jupiter* observed in Australia 1892 February 6. A. Marth.

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The orbit of *Flora*; with corrections to Brünnow's *Tafeln der Flora*. A. M. W. Downing.

Observations of Swift's Comet (*a* 1892), and Winnecke's periodical comet, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Observations of U *Orionis*. Lieut.-Col. E. E. Markwick.

Greenwich mean times of superior and inferior geocentric conjunctions of *Jupiter's* fourth satellite (*Callisto*) from 1892 November to the end of 1893. Communicated by the Superintendent of the *Nautical Almanac*.

Sextant observations of Swift's Comet. Capt. G. M. Lourison.

Observations of the variable star S *Ursæ Majoris*. C. E. Peek.

The orbit of γ *Coronæ Australis*. R. P. Sellors.

The motion of ζ *Cancri*. S. W. Burnham.

The new star in *Auriga*. S. W. Burnham.

On the orbit of Σ 2525. J. E. Gore.

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Probable error of the clock correction when both the clock rate and the instrumental constants are found by a least squares solution of a single night's observations. Rev. J. T. Hedrick.

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Observations of Brooks' Comet (*d* 1892) and Swift's Comet (*a* 1892), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On the sidereal period of the new satellite of *Jupiter*. Rev. A. Freeman.

Nova Aurigæ. E. E. Barnard.

Discovery of a comet by photography. E. E. Barnard.

Note on the period and distance of the fifth satellite of *Jupiter*. E. E. Barnard.

Corrections to Hansen's *Tables de la Lune*. J. Gordon.

On the variation of latitude as indicated by recent observations at the Royal Observatory, Greenwich. W. G. Thackeray and H. H. Turner.

On the photographic magnitude of *Nova Aurigæ*, as determined at the Royal Observatory, Greenwich. W. H. M. Christie.

Estimations of magnitude of *Nova Aurigæ*, made with the Barclay Equatoreal at the Radcliffe Observatory, Oxford. Communicated by E. J. Stone.

Observations of Holmes' Comet (*f* 1892), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On the best form of mounting for a large reflector. A. A. Common.

Dec. 9. On the spectrum of the new star in *Aurigæ*, as compared with spectra of planetary nebulæ. E. von Gothard.

The lunar eclipse, 1892, May 11–12. G. J. Newbegin.

Observations of Winnecke's periodical comet at Windsor, New South Wales. J. Tebbutt.

The binary star Σ 1785. S. W. Burnham.

Photographs of Comet Holmes. Isaac Roberts.

Observations of Holmes' Comet, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Elements of Comet Holmes. E. Roberts.

Note on an occultation of D.M. + 4°·123 (mag. 6·5) by *Mars* on 1893 January 14. A. M. W. Downing.

1893.

Jan. 13. The secular perturbations of the Earth arising from the action of *Venus*. R. T. A. Innes.

The eclipse of the Moon, 1892 November 4–5, observed at Sydney Observatory. Communicated by H. C. Russell

Observations of the phenomena of *Jupiter's* satellites at Bermerside Observatory, Halifax, in the year 1892. J. Gledhill.

Note on the Red Spot on *Jupiter*. J. Gledhill.

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Photograph of the nebula H I. 55 *Pegasi.* Isaac Roberts.

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The *Geminid* meteor shower. W. F. Denning.

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On the variation of latitude by the Greenwich transit-circle observations. S C. Chandler.

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On the determination of the equations for the perturbation of the inclination and node of an orbit by the method of variation of constants. R. Bryant.

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ADDRESS

Delivered by the President, Mr. E. B. Knobel, on presenting the Gold Medal to Professor H. C. Vogel.

The Council have awarded the Gold Medal to Dr. Hermann Carl Vogel for his "Spectroscopic and Other Astronomical Observations," and it is now my privilege to lay before you some of the considerations which have influenced them, in bestowing the highest honour in their power, upon the Director of the Astrophysical Observatory at Potsdam.

In reviewing the numerous observations and researches, conducted with such refinement and high intelligence as distinguishes Dr. Vogel's career as an astronomer, it is, perhaps, natural that our attention should first be given to those spectroscopic investigations by which he has more conspicuously enriched our science, and in which he has developed a precision that is both exceptional and remarkable.

It seems probable, that researches in stellar astronomy which depend upon the analysis of the light emitted by the stars, will afford us in some respects results available for more exact conclusions, than those made by the ordinary methods of observation and measurement. By the latter, we are able to determine the movements of stars transversely to the line of sight, but only in angular measures, which, save in a very few cases, cannot be translated into units of distance, and in those instances the probable errors are very large. But, incredible as it would seem, the spectroscope, wielded with such delicate and refined skill as characterises the researches we have to consider, teaches us the velocity at which stars are approaching or receding from the earth, with a probable error which may be even less than a mile per second of time.

Such precision as has been attained, reveals to us a means of partially unravelling some of the complexities of the stellar movements, and enables us to penetrate into some of the mysteries of the universe of stars, which a few years ago would have been considered altogether beyond the human intellect to unfold. Not only are we thus able to ascertain the general drift of stars and star-systems, but also to obtain an imperishable record of the internal motions within those systems.

The physical principle underlying such investigations, is of a sufficiently simple character; and was first suggested by Doppler

in 1841, as an extension of the principle on which he had shown that a sound should become sharper or flatter, if there were an approach or a recession between the ear and the source of the sound. Doppler supposed that stars might in this way change their colour as observed by eye, but he did not know of the stores of invisible light beyond both limits of the visible spectrum, ready to be lowered or raised into visibility, so that, as a matter of fact, no such change of colour would occur.

In 1848, Fizeau investigated the theory of Doppler with regard to sound, and offered an experimental proof of its correctness; and, in applying it to light, he pointed out the importance of considering the individual wave-lengths, and mentioned that though the enormous velocity of light presented a great difficulty in any experimental demonstration, he nevertheless expressed a confident belief that such proof would eventually be forthcoming. But it was not until spectrum analysis had enabled us to detect the lines of terrestrial substances in the stars, that this principle, in the hands of Huggins, became, in 1868, of practical importance in astronomy.

Eight years ago the high value of physical researches on the motion of stars in the line of sight, was acknowledged by the Council, in awarding the Gold Medal to him, to whom the honour justly belongs of originating this branch of observational astronomy—our Foreign Secretary, Dr. Huggins.

In the address delivered on that occasion by the President, Mr. Dunkin, the history of Dr. Huggins's important researches was clearly set forth, and it will be remembered that his observations were first published in the *Philosophical Transactions* for 1868.

About this time, Dr. Vogel commenced astrophysical investigations at the University Observatory of Leipzig, his interest in this study having been excited by his acquaintance with Zöllner; and in 1869, not long after the important discovery of Lockyer and Janssen, he assisted Zöllner in his spectroscopic observations of the solar prominences. But on his appointment to Von Bülow's private observatory at Bothkamp in 1870, he devoted himself more particularly to stellar spectroscopy, and prominently to that branch which had yielded Dr. Huggins such brilliant results.

It must be remembered that at this time the subject was young, and it had been shown by its founder that the utmost accuracy in the construction of the apparatus employed was essential. Instruments had to be invented and their errors determined with the greatest nicety; and Dr. Vogel's appreciation of these difficulties was well manifested in his minute attention to the details of his apparatus.

The spectroscope he employed, was constructed by Schröder, and consisted of five direct vision prisms, with a refracting angle of 90°. The special features of the instrument were—the object glass of the telescope being of the same aperture and focal

length as the collimator lens, and the size of the latter being adapted to the cone of light coming from the object glass of the large 11½-inch refractor, so that all the rays could be made use of. Great stability was insured by special supports, and the performance of the instrument left nothing to be desired.

The comparison hydrogen-spectrum was so arranged, that the bright lines of the gas spectrum should extend across the whole field of view of the telescope. In this way the bright lines were seen on either side of the band-like stellar-spectrum, and thus any error from the estimation of coincidence of two lines, on one side only, was eliminated.

With this apparatus, Dr. Vogel, in the year 1871, observed and measured the principal lines in the spectra of several stars, reducing them to wave-lengths, and adopting the scale given in Ångström's chart. He measured the displacement of the F hydrogen line in the spectra of *Sirius*, *Procyon*, *Capella*, *Altair*, and *Vega*, and his determination of their motions in the line of sight, published in the *Astronomische Nachrichten*, was strikingly confirmatory of the results previously obtained by Huggins.

Viewing these observations under the light of more recent researches, it must be admitted that the instrumental means employed were hardly adequate for so delicate an inquiry, and the amount of these motions must necessarily be considered only as approximate.

For four years Dr. Vogel pursued his spectroscopic researches at the Bothkamp Observatory, not only in measuring the spectra of stars, and the determination of their motions in the line of sight, but in other directions which will be referred to later on. It may be sufficient to say here, that it was the excellence and success of his work at this observatory, in so many new directions, that led to the founding of the Astrophysical Observatory at Potsdam in the year 1874. Of the extent and importance of the work done at this institution, through the origination, and under the superintendence, of Dr. Vogel, the eight volumes of published results bear ample testimony.

For fifteen or sixteen years, the method of determining the motions of stars in the line of sight had remained undeveloped from the condition in which it left the hands of Huggins, and no progress was made in the accuracy attained by him. But about the year 1887, experiments were made at Potsdam by a photographic application of the method, which showed that a sufficiently great dispersion could be made use of, to readily detect and measure the displacement of the spectral lines produced by the radial motion of the stars.

In his memoir already referred to, published in 1868, Dr. Huggins mentions that the chief difficulties he had to encounter, in spectroscopic observations of the stars, arose from the unsteadiness of the atmosphere. Unless the air is very steady, the lines were seen too fitfully to permit of any certainty in the determination of coincidences of the degree of delicacy required

in his investigations. He says that he "passed hours in the attempt to determine the position of a single line, and had then not considered that the numerous observations which he had obtained were possessed, even collectively, of sufficient weight to establish with any certainty the coincidence of the line with the one compared with it." One remarkable result of Dr. Vogel's photographic method, was the discovery that the disturbances of the atmosphere exert their influence in a lesser degree on the photograph than on the eye in direct observations. Such unsteadiness in our atmosphere, as would defeat all attempts at accurate eye observation, is of little consequence when the rays are allowed to fall upon the sensitive photographic plate. The continually varying refractions which cause the star image to be at one instant on the slit of the spectroscope, and the next instant off it, appear to be of small moment, for they only affect the time of exposure. The plate faithfully records all the rays that fall upon it, however rapidly these alternate appearances and disappearances recur.

The application of photography to the determination of the motions of stars in the line of sight, in the hands of Dr. Vogel, assisted by Dr. Scheiner, has yielded results which are nothing short of surprising; and the investigation has been conducted with such refined and scrupulous attention to the elimination of errors, as renders it worthy of our highest acknowledgment.

These researches are contained in the seventh volume of the Publications of the Astrophysical Observatory at Potsdam, and the observations were made in the years 1888 to 1890.

In the construction of the apparatus—called the Spectrograph—the following points were taken into consideration:—Great stability for the smallest possible weight; suitable dimensions of prisms, collimator, and camera objectives, in order to preserve sufficient brightness with the greatest possible dispersion; accurate adjustment of the photographic plate in the focal plane of the camera objective; and exact keeping of the star on the slit of the spectrograph. The first two conditions were satisfied by making the frame of cast steel, and by giving it a form which offered the greatest possible resistance to flexure. The detailed construction of the apparatus has already been given in the publications of the Society, and further repetition is hardly necessary. Suffice it to say that the utmost attention was given to secure such stability that very small displacements of the lines in the stellar spectra could be photographed and measured.

The performance of the instrument was tested on the Sun by direct observations, and by photographs; and the accuracy of the measures, as well as the correctness of the adjustment, are well and most satisfactorily indicated by the following observations of the motion of *Venus*:—

	Observed Velocity.	Calculated Velocity.
1889 Jan. 2	−7·8	−7·4 English miles
Feb. 10	−7·4	−7·8 „

No better proof than these figures afford, could be given of the refinement which Dr. Vogel has introduced into every part of his work. In particular, he has taken the greatest precaution in respect of the insidious influence of changes of temperature on the apparatus generally, and especially in the comparison of stellar photographs under the microscope with solar ones taken at a different temperature.

He has employed different methods of measurement under the microscope of the displacement of the stellar lines relatively to the artificial ones, according to the type of star and the character of its lines. These are, however, of too technical a nature for detailed description on this occasion, and I must therefore refer to his original memoir, where every part of his investigation is fully described. Mention should, perhaps, be made of his employment of the spectrum of iron for comparison with *Sirius* and some other stars. He was thus able to measure the displacement in as many as eleven different iron lines compared with stellar ones.

The first important result obtained, was the proof of the influence of the Earth's motion on the displacement of the lines, which the earlier direct observations had failed to show with accuracy. As examples, I quote the results for three stars.

	Observed Velocity.	Earth's Velocity.	Velocity of Star reduced to the Sun.	
		α Tauri.		
1888 Oct. 28	+18·1	− 9·5	+27·6	English miles
Nov. 10	+24·9	− 5·9	+30·8	,,
Dec. 4	+30·6	+ 1·8	+28·8	,,
1890 Jan. 9	+43·7	+12·3	+31·4	,,
		α Ophiuchi.		
1888 Sept. 30	+27·6	+14·1	+13·5	,,
1889 June 7	+ 9·7	− 1·0	+10·7	,,
		α Ursæ Majoris.		
1888 Nov. 7	−17·0	−11·9	− 5·1	,,
9	−18·1	−11·9	− 6·2	,,
1889 May 4	+ 5·2	+11·8	− 6·6	,,
22	+ 3·4	+11·2	− 7·8	,,

The consideration of these remarkable results will at once suggest the question: May we not be able, in the future, by the spectroscopic measurement of the radial motions of stars, to determine the earth's velocity in her orbit? In that case, we shall be forced to the astounding conclusion that by observations

of stars, whose parallactic displacement is absolutely insensible, we are yet able to determine the important unit of measurement in our system—the solar parallax.

The difficulties in the early observations arising from atmospheric tremor, to which I have already referred, disappear in great measure when a much more powerful spectroscope is employed, so that the difference of position between the star line and the comparison line, is much more obvious to the eye. Especially is this the case when the great dispersion of a modern grating is made use of.

Armed with these advantages, Keeler has shown that on *objects which are bright enough*, the eye can well hold its own as compared with the photographic plate. His measures of *Venus* show well what the eye can do.

Venus.

	Observed Motion.	Calculated Motion.
1890 Aug. 16	−7·3	−8·1 miles
22	−8·9	−8·2 „
30	−7·3	−8·3 „
Sept. 3	−8·3	−8·3 „
4	−8·2	−8·3 „

It is especially gratifying to find that, in the case of a star of sufficient brightness, and which possesses a suitable spectrum, the eye observations at the Lick Observatory agree minutely with the results of the measurements of the photographic plates at Potsdam.

Arcturus.

Mean of observations at Potsdam −4·4 ± 0·2

Mt. Hamilton (Keeler).

1890 Apr. 10	−4·6 miles
Aug. 7	−4·0 „
15	−4·2 „
Mean	−4·3

There can now be no longer any hesitation in accepting the motions which Dr. Vogel has given us of his fifty-one stars, as, indeed, very near the truth; and in recognising the immense importance of this method of astronomical observation.

The photographic work at Potsdam has not only given to us the radial motions of fifty-one stars, but from it have resulted two discoveries of very high interest—namely, the compound nature and true cause of the variability of *Algol*; and the duplicity of *Spica*, where, from the inclination of the orbit relatively to the

line of sight, no variation of its light is produced by its obscure companion.

Indeed, at Harvard, the discovery of two remarkable binary stars had already been made—namely, *ζ Ursæ Majoris*, and *β Aurigæ*, but the Harvard photographs, taken with a slitless form of spectroscope (the prisms being arranged before the object glass of the telescope in the manner first used by Fraunhofer, and later revived by Secchi), do not permit of a direct comparison of the star's spectrum with terrestrial spectra.

In the case of the binary star *Algol*, only one star is bright, and, consequently, there would be no doubling of the lines as shown in the Harvard photographs of *β Aurigæ*. but only a small shift of the lines to and fro in the spectrum, as the bright star moved in its orbit towards or from the Earth, and this would need for its detection the fiducial positions of terrestrial lines for comparison with them.

Twelve photographs of *Algol*, taken by Dr. Vogel in the years 1888 to 1891, when his researches on stellar motion terminated, were measured independently by him and by Dr. Scheiner, and the comparison of their results, when reduced to the Sun, show, what is practically, perfect agreement. From the discussion of the displacement of the lines, our Medallist made the interesting discovery of a motion of approach and recess, corresponding to the known variation of its light of 68·8 hours.

Thus, the explanation suggested by Goodricke, a century ago, that the variability of *Algol* was due to the periodic transit of an opaque body revolving round the star, was proved to be the true one.

The Potsdam photographs show that before minimum the bright star is receding at the rate of 24·4 English miles a second, while after the minimum has been passed the star approaches us with the velocity of 28·6 miles a second. From these velocities it follows that the system of *Algol* is approaching our system at the rate of 2·3 miles a second, and that the visible star has a velocity in its orbit of 26·3 miles. Assuming that both the bright and dark components have the same density, so that their masses are directly as their volumes, Dr. Vogel gives the following particulars of the system :—

	English Miles.
Diameter of *Algol*	1,061,000
Diameter of dark companion	830,300
Distance of centre	3,230,000
Motion of *Algol* in its orbit	26·3 miles per second
Motion of companion	55·4 „ „
Mass of *Algol*	$\frac{4}{5}$ of Sun's mass
Mass of companion	$\frac{2}{5}$ „

In the case of *Spica* the method followed was to photo-

graph on the same plate the spectrum of the star and that of terrestrial hydrogen, and the displacement of the star lines was measured with the microscope. These measurements were made with considerable difficulty, owing to the fact that the hydrogen lines in the spectrum of this star are broad and ill-defined; and in this and similar cases a special method had in consequence to be adopted. The result of the measurement of twenty-seven photographs, was to show that the star lines are displaced alternately towards the red and violet ends of the spectrum, in a complete period of about four days, the maximum displacement towards the violet, indicating a motion towards the Sun of 65·9 English miles, and that towards the red, a receding motion of 47·5 miles.

These observations are completely explained on the supposition that *Spica* is a binary star, one component of which is too faint to be detected by any means at present at our disposal. The orbital velocity of the bright star is 56·7 miles a second, and the system is approaching the Sun at the rate of 9·2 miles a second. The following are the elements:—

α Virginis.

Velocity in line of sight − velocity of system = 56·7 sin $\left(\frac{t-t_0}{p}\right)$ 360° in miles

Velocity of system = − 9·2 miles

Period p = 4·0134 days

Epoch t_0 = 1890 May 4, 10^h·50 Potsdam m. t.

Assuming a circular orbit, and that the components have equal mass, then the mass of the system is 2·6 times that of the sun, and the components are separated by about 6¼ millions of miles. Taking the most probable value for the star's parallax, the angular separation of the stars would be 0″·014, a quantity far too small to be detected by the most powerful telescopes.

It should be mentioned that Dr. Vogel conceives that some traces of the spectrum of the faint companion can be made out in the photographs, in the unsymmetrical appearance of the hydrogen lines at the time of maximum motion, and a greater sharpness of other lines at the time of minimum motion.

The new light thrown upon the constitution of the heavens by these remarkable discoveries excites our imagination in the highest degree, and may easily lead us into the wide fields of conjecture and speculation; for there can be little doubt that many such systems exist, which future observations will make known to us. The spectacle of two suns, each as large as our own, revolving round each other in a few days, is one that has been revealed to us by indirect means it is true; but it is also true that the evidence depends upon laws and principles so well investigated, and so well understood, that what might

otherwise bear the aspect of romance, must be accepted as a logical, scientific, and indisputable deduction.

Before passing from this subject, I should not omit to state that shortly after Dr. Huggins's original observations, the new method of observation of radial motions was taken up systematically at the Royal Observatory, Greenwich, and at the Temple Observatory, Rugby. From 1874 until 1890 the work was pursued assiduously at Greenwich, and every observation made has been communicated to the Society and published in the *Monthly Notices*.

To secure accurate data by which posterity may be able to recognise the changes that are possibly continually, and progressively, taking place in the heavens, is an important duty that devolves upon us in return for the enormous advantages and facilities which modern scientific research has placed at our disposal. It was the recognition of this obligation that brought about the recent international organisation for the construction of a photographic chart of the heavens, and it was the same consideration in the mind of our Medallist that led him to commence the laborious work of a Spectroscopic *Durchmusterung*. To this intent, Dr. Vogel, assisted by Dr. Müller, in the years 1880 to 1882, observed the spectra of all stars to the 7·5 magnitude situated in the zone between the parallels of 1° south and 20° north declination.

The results were published in the third volume of the publications of the Potsdam Observatory, and form a catalogue of the spectra of 4,051 stars.

It is very gratifying to note that this important undertaking has now been completed between the Pole and 15° south declination: the observations between the Equator and −15° having been made by Dr. Konkoly at the O'Gyalla Observatory, and those from 20° north declination to the Pole by Dr. Dunér.

The spectra of the stars examined by Dr. Vogel are classified according to the three types of the system adopted by him. It will be remembered that from his voluminous researches he had been led to a classification of stellar spectra differing somewhat from that adopted by Secchi, inasmuch as he combines the third and fourth types of the latter physicist, into one division. Accepting the hypothesis of Zöllner, that yellow and red stars are simply white stars in various stages of cooling, he considered the white stars of Class I. as the hottest and youngest members of the sidereal family; those of the Solar type, as having wasted much of their store of radiation; while the red stars with banded spectra are viewed as "effete suns hastening rapidly down the road to final extinction." But whatever views may come to be adopted ultimately of the relation to each other of the different stellar types, Dr. Vogel's system of arrangement has been of considerable assistance in the record and comparison of stellar spectra.

In solar physics Dr. Vogel's researches place him in the

forefront of those who have laboured at this branch of astronomy, created by the invention of the spectroscope. While at Bothkamp numerous observations were made, and the discoveries that resulted are of much interest.

It had occurred to both Secchi and Zöllner, that from the unequal displacement of the F or the C line, when observed at the two opposite points of the Sun's equator, the velocity of solar rotation might be ascertained. If a spectrum line be observed on the eastern limb of the Sun, which is approaching the observer, it will, in comparison with its position in the centre of the disc, appear to be displaced towards the violet, whereas observations of that line on the western limb, which is receding from us, would show a displacement in the opposite direction. For such a delicate investigation, Zöllner had invented a Reversion-Spectroscope, by which instrument two spectra could be brought into juxtaposition, but with the lines in reverse order, so that the measurable effect of any displacement of the lines would be doubled, as the deviation in each spectrum is in an opposite direction.

With such an instrument Dr. Vogel, in 1871, at Bothkamp, while observing the Sun's limb, was able to detect an undoubted displacement of the F line, the cause of which was traceable to the Sun's rotation, and thus for the first time the *fact* of rotation was proved by the spectroscope.

This method of determining the rotation of the Sun, has recently been very successfully developed by Dr. Dunér, who has succeeded, not only in measuring the displacement of the lines on the solar equator, and so measuring the velocity of equatorial rotation, but has also been able to measure the diminution of the angular velocity of rotation in higher heliocentric latitudes, which had been discovered from observations of sunspots.

No better test, if such were needed, could be devised of the soundness of the conclusions as to the cause of such displacements in the observations of stellar spectra.

In the year 1877 the intensity of solar radiation occupied the attention of Dr. Vogel. It had been earlier remarked by Secchi in his investigation of the absorption of the solar atmosphere on the luminous rays, that the light from the limb of the Sun is not white, but reddish-brown. This indication of selective absorption, showed the importance of investigating by some photometric method, the loss suffered by rays of different refrangibilities.

Our Medallist was thus led to design a new spectrum-photometer, which was constructed on the principle of the polarising photometer invented by Glans. The results he obtained with this instrument are of the greatest interest.

In his skilful hands, he was able to compare with great accuracy and directly, the brightness of the rays of different refrangibilities proceeding from different parts of the Sun's disc.

The results are contained in the following table. In the first

column is given the distance of the point from the Sun's centre in percentage of the Sun's radius, and the other columns give the ratio between the light of the given colour at the centre and at the given point.

D	Violet $\frac{412}{405}\}\mu\mu$	Dark Blue $\frac{446}{440}\}\mu\mu$	Blue $\frac{473}{467}\}\mu\mu$	Green $\frac{515}{510}\}\mu\mu$	Yellow $\frac{585}{573}\}\mu\mu$	Red $\frac{666}{658}\}\mu\mu$
0	100·0	100·0	100·0	100·0	100·0	100·0
5	99·9	99·9	99·9	99·9	99·9	100·0
10	99·6	99·7	99·7	99·7	99·8	99·9
15	99·2	99·3	99·3	99·3	99·5	99·7
20	98·5	98·7	98·8	98·7	99·2	99·5
25	97·5	97·8	98·1	97·9	98·8	99·3
30	96·3	96·8	97·2	96·9	98·2	98·9
35	95·0	95·6	96·1	95·7	97·5	98·5
40	93·4	94·1	94·7	94·3	96·7	98·0
45	91·2	92·2	93·1	92·6	95·7	97·4
50	88·7	90·2	91·3	90·7	94·5	96·7
55	85·7	87·8	89·3	88·6	92·9	95·9
60	82·4	84·9	87·0	86·2	90·9	94·8
65	78·7	81·7	84·2	83·4	88·0	93·2
70	74·4	77·8	80·8	80·0	84·5	91·0
75	69·4	73·0	76·7	75·9	80·1	88·1
80	63·7	67·0	71·7	70·9	74·6	84·3
85	56·7	59·6	65·5	64·7	67·7	79·0
90	47·7	50·2	57·6	56·6	59·0	71·0
95	34·7	35·0	45·6	44·0	46·0	58·0
100	13·0	14·0	16·0	16·0	25·0	30·0

The consideration of these figures shows that of the violet rays, only 13 per cent. penetrate the solar atmosphere at the limb, of the indigo 14 per cent., of the blue and green 16 per cent., 25 per cent. of the yellow, and 30 per cent. of the red.

From the complete analysis of the Sun's light from the centre to the edge of the disc afforded by the above table, we see that the colour at the limb must be different from that at the centre of the disc, since more of the violet rays are absorbed than the red. The observations show, also, a much more rapid degradation of the light towards the limb, and so indicate a thin and dense atmosphere. In discussing his results, according to the fundamental law of radiation that an incandescent sphere appears sensibly of equal brightness all over, the foreshortening of each area inclined to the line of sight compensating for its diminished radiation, Dr. Vogel finds that if the absorbing

envelope of the Sun were removed, the brightness of the red rays of the visible spectrum would be increased about 1·49 times, and the violet rays 3·01 times.

The rapid development of spectroscopy soon rendered necessary a reconstruction and completion of Ångström's Map of the Solar Spectrum. This work, which was first undertaken by Mr. Lockyer, was subsequently taken up by Dr. Vogel at Potsdam, who made a long series of accurate measures, and took a vast number of photographs between F and H—from 489 to 389 millionths of a millimetre of wave-length; and the result is a map of this portion of the solar spectrum no less than 17 feet long. The less refrangible end was later completed by Dr. Müller. Under Dr. Vogel's superintendence, Drs. Müller and Kempf made original determinations of the wave-lengths of 300 lines, by the aid of which the wave-lengths of all the lines in the Potsdam map were newly fixed with an accuracy considerably greater than that of the scale of Ångström, then almost exclusively in use.

Not the least valuable of the spectroscopic observations, pursued with the same unwearying assiduity by our Medallist, are those he made on the spectra of the planets.

In examining the spectra of bodies like the planets, which shine solely by the reflected light of the Sun, the only differences from the solar spectrum we should expect to find, would be those due to the absorbing influences of their atmospheres. Such absorption bands had been measured in the principal planets by Huggins and Secchi, but at Bothkamp Dr. Vogel succeeded in making the most complete measurements we possess of the lines in the spectra of all the planets, and determined the refrangibility of the principal absorption bands. The interesting question of the causes of some of these bands is at present undecided, and though the observations indicate the existence of aqueous vapour in the atmospheres of some of the planets, yet bands were observed by him in the spectra of *Jupiter*, *Saturn*, and *Uranus*, which suggest a difference in the constitution of the gaseous envelopes surrounding those planets compared with that of our terrestrial atmosphere. For these important researches Dr. Vogel was awarded a prize by the Copenhagen Academy.

Besides observing the spectra of Nebulæ, Clusters, and Comets, he, in 1871, instituted measures of the bright lines visible in the spectrum of the Aurora, and determined with great exactness the wave-lengths of about seven lines. Hitherto the identification of the Auroral spectrum has not been satisfactorily established, the principal line in the green being quite unknown. Dr. Vogel, however, was strongly inclined to the opinion that the spectrum is merely a modification of that of air, but the origin of these lines is still an open question.

The spectrum of Lightning also engaged his attention, and, notwithstanding the difficulty of such observations, the positions of the brightest lines were accurately measured by him and Dr.

Lohse with the stellar spectroscope of the Bothkamp Observatory. Suffice it to say that his observations appear to have been fully confirmed by those made more recently.

In determining this award the Council desired to include other astronomical researches of Dr. Vogel, apart from those depending on the spectroscope, and it is my duty here to allude to them, though in the briefest terms.

While an assistant at the Leipzig Observatory he made two important series of observations on nebulæ and clusters, in which the positions of about 240 of these objects were determined with an exactness sufficient to make them of great value in any discussion of nebular parallax. In this respect these observations of Dr. Vogel have probably not been surpassed. At this period, also, he prepared a memoir giving the results of his micrometric measures and photometric determination of 176 stars, ranging from 6·5 to 13 magnitude, in one portion of the great cluster in *Perseus*; the investigation of the other portion of this double cluster having been previously made by Krüger at Helsingfors. In this work, the care exercised in the determination of the zero of position, and in the investigation of the micrometer, are characteristic of the author; and the accuracy of the results is satisfactorily shown by the very small probable errors of the positions of the brighter stars, and by the indication in one of them, of a possible parallax of $0''\cdot3$. In undertaking these researches his object was to fix relative positions, so that any future change might be detected. Probably, however, in the future we shall rely more upon the photographic astronomer to discover and inform us of changes in the heavens, than upon such laborious investigations as those made with the micrometer.

Finally, I would desire to refer to our Medallist's observations of *Jupiter's* satellites.

The determination of the mass of *Jupiter* has been repeatedly undertaken, and the values we possess of this important constant, have been derived either from heliometer measures, and transit observations of the satellites, or from planetary perturbations. In order to furnish additional data for such an inquiry, Dr. Vogel, while at Leipzig, made a long series of transit observations of the 3rd and 4th Satellites. These observations have been used by Dr. Kempf in his investigation of the mass of *Jupiter* contained in the third volume of the Potsdam publications, in which he combines the most reliable researches that had been made on the subject. His definitive result of $\frac{1}{1047\cdot700}$ differs insensibly from the value of $\frac{1}{1047\cdot767}$ derived from Dr. Vogel's observations alone. This satisfactory agreement indicates clearly the excellence of his Leipzig observations, which were made in the years 1868 to 1870.

In the brief and very imperfect review of Dr. Vogel's labours which I have brought before you, I can scarcely hope to have

succeeded in adequately explaining the admirable services which he has rendered to Astronomy. I have dwelt upon the refined character of his observations, and the extreme care with which all his researches have been conducted. It is a record of unwearying perseverance to accomplish great work; moreover, it is the chronicle of a masterly attainment of success.

Such achievements as those gained by the spectroscope at Potsdam, reveal to us what Lubbock happily terms "the exquisite possibilities of science." Not only is Astronomy enriched by a series of investigations of the greatest value, but a distinct, and, indeed, marvellous advance is made in our knowledge and conception of the stellar universe.

Notwithstanding many deficiencies, I trust I have been able to justify the action of the Council to you, in their desire to honour, in the highest degree, one who has laboured so earnestly, so devotedly, and with such distinguished success for our science.

The President then, delivering the Medal to the Foreign Secretary, addressed him in the following terms:—

Dr. Huggins, It is with peculiar interest I place in your hands this medal, and request you to transmit it to our distinguished Associate Dr. Vogel, who, we much regret, is unable to be present to-day; for I can well understand the satisfaction it must be to you, who occupy so classic a position in Spectroscopic Astronomy, to be the medium of conveying this mark of our highest appreciation to one who has developed with such signal success the branch of Observational Astronomy which you originated in 1868. In congratulating him upon the splendid results he has obtained, we would, at the same time, express the full satisfaction with which we have watched the progress of the important institution he directs, and our obligations for its great services to Astrophysics. Assure him of our continued interest in his valuable researches, and that we trust the knowledge of the high estimation in which they are held, may stimulate him to even greater and more noble achievements, which, with the blessing of health and strength, we confidently expect from him.

The meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President.

Captain W. de W. Abney, C.B., R.E., D.C.L, F.R.S.

Vice-Presidents.

W. H. M. Christie, Esq., M.A., F.R.S., Astronomer Royal.
A. M. W. Downing, Esq., M.A., D.Sc., Superintendent of the "Nautical Almanac."
E. B. Knobel, Esq
Lieut.-Gen. J. F. Tennant, C.I.E., R.E., F.R.S.

Treasurer.

A. A. Common, Esq., LL.D., F.R.S.

Secretaries.

E. W. Maunder, Esq.
H. H. Turner, Esq., M.A., B.Sc.

Foreign Secretary.

William Huggins, Esq., LL.D., D.C.L., F.R.S.

Council.

Sir R. S. Ball, LL.D., F.R.S., Lowndean Professor of Astronomy and Geometry, Cambridge.
J. W. L. Glaisher, Esq., M.A., Sc.D., F.R.S.
Frank McClean, Esq., M.A.
W. H. Maw, Esq.
H. F. Newall, Esq., M.A.
Captain William Noble.
W. E. Plummer, Esq., M.A.
A. Cowper Ranyard, Esq., M.A.
Isaac Roberts, Esq., D.Sc., F.R.S.
Rev. Walter Sidgreaves, S.J.
E. J. Spitta, Esq.
E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. MARCH 10, 1893. No. 5

Captain W. DE W. ABNEY, C.B., R.E., D.C.L., F.R.S., President, in the Chair.

Maurice Anderson Ainslie, B.A., Giggleswick School, near Settle, Yorkshire;
James Arthur Formoy, F.C.S., Lestelle, London Road, Forest Hill, S.E.;
Henry Bateman Massey, Spalding, Lincolnshire;
John Mills, 11 Henrietta Street, Covent Garden, W.C., and 44 Orbel Street, Battersea Park, S.W.; and
Edward Turner Whitelow, 70 Deansgate, Manchester,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers, from personal knowledge, being appended :—

Walter Frederick Gale, M.R.S. of N.S.W., The Observatory, Paddington, New South Wales, Australia (proposed by H. C. Russell);
The Rev. P. H. Kempthorne, M.A., late Fellow of St. John's College, Cambridge, Tutor and Assistant Master at Wellington College, Berks (proposed by Sir R. S. Ball);
James Henry Young, B.Sc. Lond., H.M. Office of Works, The Dell, Tooting Graveney, Surrey (proposed by Robert Bryant).

One hundred and sixteen presents were announced as having been received since the last meeting, including, amongst others:—

Transactions of the Yale University Observatory, vol. i. parts 3 and 4, presented by the Observatory; Harvard College Observatory Annals, vol. xv. part 2, catalogue of 8,627 stars, presented by the Observatory; R. A. Proctor and A. Cowper Ranyard, Old and New Astronomy, presented by Mr. Ranyard; J. de Mendizábal Tamborrel, Tables de Logarithmes, presented by the author; Amy Johnson, Sunshine, presented by the author; Karlsruhe Observatory, Veröffentlichungen, Heft IV., presented by the Observatory; Photographs of the Milky Way, minor planets, meteor tracks, &c., presented by Dr. Max Wolf, per Mr. A. Taylor; Positive enlargements of photographs of *Jupiter* made at the Lick Observatory, presented by the Observatory; Further portion of a series of photographs of the Presidents of the Society, presented by Mr. W. Schooling; Enlargements from a series of negatives of the region surrounding η *Argûs*, and other astronomical photographs made at the Cape Observatory, presented by Dr. Gill.

Photographs of past Presidents of the Society.

It has already been announced that Mr. Schooling is presenting to the Society a series of beautiful photographs of the past presidents, and two instalments have been warmly acknowledged at evening meetings. To complete the series Mr. Schooling would be glad of the loan of portraits of the following:—

H. T. Colebrooke (1823–24),
Bishop Brinkley (1831–32),
Manuel J. Johnson (1855–56),
Warren De la Rue (1864–65),

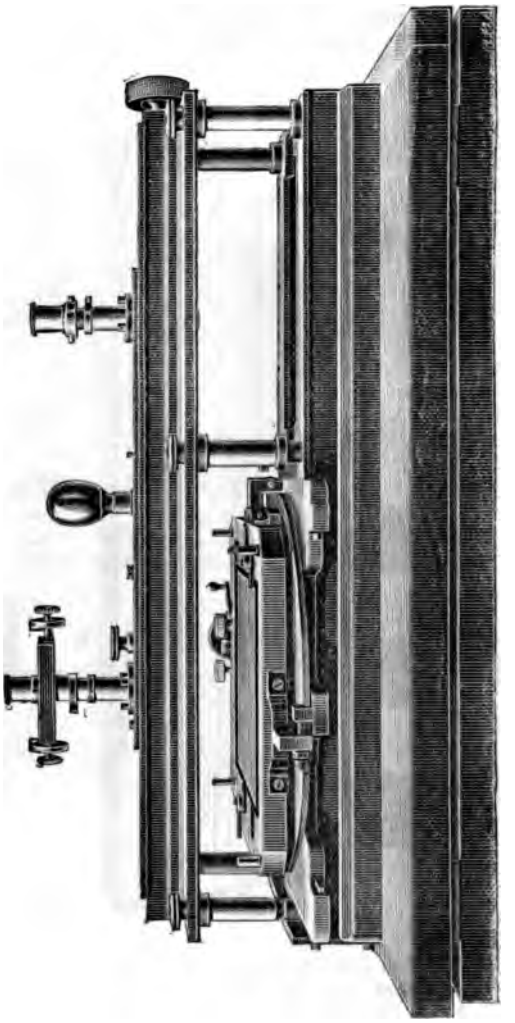
and any information which might help him to this end will be gratefully received either by him or by the secretaries.

A Micrometer for measuring the Plates of the Astrophotographic Chart. By W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

For the measurement of the catalogue plates of the Astrophotographic Chart, the micrometric slide originally made by Messrs. Troughton & Simms for the measurement of the distance of *Venus* from the Sun's centre on the transit of *Venus* photographs, 1874, by the help of an auxiliary millimetre scale on plate-glass, has been adapted to the ready determination of rectangular coordinates and diameters of disks of stars on $16^{cm} \times 16^{cm}$ plates.

The two figures will give an idea of the general arrangement.

Two microscopes, rigidly connected, are mounted in a longitudinal hollow frame or slide, which can be moved quickly by hand to any position in a long slide, and clamped securely.

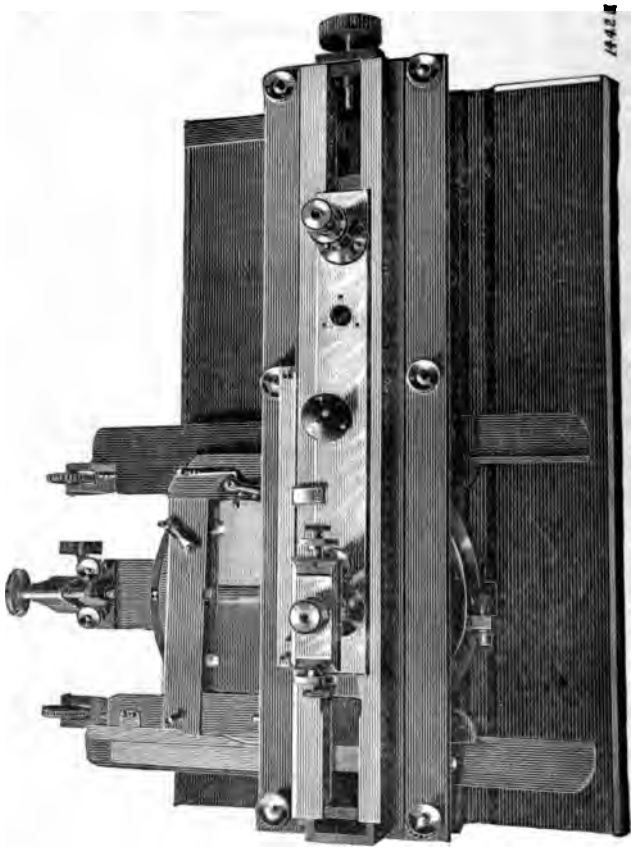


MICROMETER FOR STELLAR PHOTOGRAPHS, ROYAL OBSERVATORY, GREENWICH.

FIG. 1.—View nearly in plane of photograph.

A slow motion can be given to this latter and to the frame carrying the two microscopes by means of a screw, shown on the right. The photographic plate (in a suitable frame) is viewed by the left-hand microscope (which is provided with a parallel-

wire micrometer, to be described presently), and a glass scale, divided into millimetres, is viewed by the other. The plate is held in its frame, with film uppermost, in precisely the same manner as in the plateholder at the breech end of the photo-telescope, being pressed laterally by springs against two studs on one side (for orientation), and against one stud in the middle of the adjacent side (for fixity of position), the film side being kept



Micrometer for Stellar Photographs, Royal Observatory, Greenwich.

Fig. 2.—View from above.

in bearing with three studs in the focal plane of the microscope (at two corners and the middle of the side opposite) by three springs immediately below. The frame in which the plate is held is capable of rotation through 90°, banking against adjustable screws so that the cross lines of the réseau can be successively placed parallel to the micrometer slide and coordinates measured in the two directions at right angles. It is, further, mounted in a slide perpendicular to the micrometer slide (with adjustment

for accurate perpendicularity), so that by the longitudinal motion of the microscope and the transverse motion of the photograph, any point of the latter can be brought under the microscope, the approximate coordinates being read off by millimetre scales attached to the two slides. The whole instrument is mounted on a hinged wooden frame, so that the plane of the photograph can be tilted to any convenient angle for vision by transmitted light from a reflector or white paper below, the plate and frame being counterpoised by two weights running over pulleys at the top of the transverse slide.

The star to be measured having been brought near the centre of the field of the left-hand microscope by the quick motion, the microscope frame is clamped, and, by means of the slow motion, the corresponding division of the millimetre scale is bisected by the fixed parallel wires of the right-hand microscope. The star is then measured with the left-hand micrometer-microscope. This is arranged to give readily the reading for the centre of the star's disk and its diameter, the principle being that devised by Sir G. B. Airy for the Reflex Zenith Tube at Greenwich. There are two micrometers, A carrying its own wire and also the bearing of B, which carries a parallel wire. The screws for A and B have the same pitch, representing 20″ or $\frac{1}{3}^{mm}$ on the plate, and the heads are divided (in opposite directions) into 100 parts, so that in the sum of two readings 1 div.=0″·1. (It is intended that two readings should be taken as a rule.) It will be seen that if a and b are the readings of the two micrometers when their wires (crossed relatively to their respective heads) are placed on the two edges of the star's disk, its diameter would be b (the zero of micrometer B being adjusted for coincidence of its wire with that of A), and the reading for its centre would be $a+\frac{1}{2}b$. One coordinate having thus been measured, the plate is rotated through 90°, and the other is similarly obtained, while the photographic magnitude is inferred from the measures of diameters (by microscope B).

By this arrangement it will be seen that the positions of stars can be expeditiously found without the necessity for measurement of the lines of the réseau, and thus great labour may be saved.

Royal Observatory, Greenwich:
1893 *March* 8.

Historical Note on the Parallel Plate Double-Image Micrometer.

By J. H. Poynting.

(*Communicated by Sir R. S. Ball.*)

A description of a parallel plate double-image micrometer which I designed last year, under the belief that it was new, appeared in the *Monthly Notices*, vol. lii. No. 8, p. 556.

I have just found from the article "Micrometer" in the *Encyclopædia Britannica* that the device is more than fifty years old, having been invented by Clausen in 1841 for apparently the first time. I have not access to his description, which is given in *Ast. Nach.* xviii. 1841, col. 95–96.

In the following year the micrometer was re-invented by Porro (*C.R.* vol. xli. 1855, p. 1058). Porro used both the double-image form for the telescope and the single-image form for the microscope, with the parallel plate between stage and objective. He saw the advantage which the instrument possesses, in that it can be placed on an independent support. He was evidently convinced of the great value of the parallel plate for micrometry, and appears to have made considerable use of it. Secchi (*C.R.* vol. xli. 1855, p. 906) tried the micrometer, which he ascribed to Porro. He found it likely to be serviceable, but had not time to develope it.

Helmholtz appears to have been the third inventor of the instrument. He used it in his ophthalmometer, which is simply a short-range telescope with two parallel plates in front of the object-glass rotating in opposite directions about an axis, through equal angles. Each plate covers one half of the object-glass, and so rotation produces a double image. (*Physiol. Optik.* ed. 1867, p. 8.)

My own design appears, therefore, to stand at least fourth on the list, and I am exceedingly sorry to have troubled the Society with an account of a device as a novelty when it turns out to be so old. But though old, it is not, I am convinced, well known.

Now that I have no claim to its invention, I may perhaps fairly express the opinion that the instrument is of great value. I have used it a good deal in the single-plate form in front of the objectives of cathetometer telescopes and microscopes, and find it accurate and easy to use. It has the further merit that it is very cheap. If once introduced into laboratories I am sure that it would be found applicable—with good results—for many purposes. Should this note and its predecessor aid in such introduction, there will be some excuse for the re-invention of the instrument.

Photograph of the Nebula M. 77 Ceti. By Isaac Roberts, D.Sc., F.R.S.

The photograph was taken on 1892 November 26. Exposure 90 minutes. R.A. $2^h\ 37^m$. Decl. 0° 27′ south.

The nebula is described by Sir John Herschel as very bright, pretty large, irregularly round, suddenly much brighter in the middle, with a nucleus partially resolved. A drawing of it is given in the *Phil. Trans.* for 1861, Pl. XXV., fig. 4.

Mr. Lassell, in the *Memoirs of the Royal Astronomical Society*, vol. xxxvi., Pl. I., fig. 2, p. 40, describes the nebula, and, by a drawing, shows it to be spiral, accompanied by a near nebulous star.

Lord Rosse, in the *Observations of Nebulæ and Clusters of Stars*, p. 32, Pl. I., records twelve observations of the nebula, made between the years 1848 and 1874. The nebula is described as a spiral, with bright patches involved.

None of the drawings referred to do more than indicate some of the prominent features of the nebula, but the photograph reveals, in considerable detail, the structure and distribution of the nebulosity.

The nucleus is stellar, with projecting ansæ of dense nebulosity on the north following and south preceding sides; and surrounding this dense composite nucleus is a zone of faint nebulosity, bounded by a broad nebulous ring, which is studded with strong condensations resembling stars with irregular margins. Six or eight of the nebulous patches can, on the negative, be discerned; and if we wished to point out the formation of a stellar system, now in visible process of condensation from a nebula, this object would supply the evidence necessary in a very forcible manner to the eye.

The star to which Lassell referred is not shown to be nebulous, but is as sharply defined as any of the other stars on the plate.

An enlarged photograph from the negative is now presented, and also one shown projected on the screen.

Photograph of the Cluster M. 103 Cassiopeiæ. By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 103 Cassiopeiæ, R.A. $1^h\ 26^m$, Decl. north 60° 9′, was taken on 1892 December 23, with an exposure of 60 minutes, and the enlargement of it now presented is to the scale of 24 seconds of arc to one millimetre.

The cluster is No. 341 in the *General Catalogue* and is described by Sir J. Herschel as "bright; round; rich; pretty large; stars 10 to 11th magnitude."

The photograph shows the stars from 8th to 15th mag., and several of them have what appear to be *comites*, at a few seconds of arc distance; but this characteristic is not more remarkable in this cluster and its surroundings than it is on many other photographs which I have taken in different regions of the sky. The cluster is not strikingly round or symmetrical, nor are the stars very close together, and it is entirely free from nebulosity.

About 40 minutes of arc from the cluster, in the north following quadrant (R.A. $1^h\ 28^m$, Decl. N. 60° 48′), is a very remarkable group of stars arranged in two parallel straight lines of four each. The stars are all of about 10th mag., and the photo-disks partly overlap each other, so that the combination appears like a star trail; and, in order to make sure that it was not a trail, a second photograph was taken with a short exposure. The group is surrounded by stars of 10th to 14th mag.

Comet Holmes. By Isaac Roberts, D.Sc., F.R.S.

In the *Edinburgh Circular*, No. 37, 1893 January 17, it was announced that Professor Palisa, of Vienna, saw Comet Holmes as an 8th-magnitude fixed star with a nebulous envelope 20 seconds of arc in diameter, and Dr. Huggins had, a day or two previously, called my attention to the announcement.

A photograph of the comet was taken with the 20-inch reflector on January 18, and exposure of 30 minutes, upon which it appeared as a very dense circular nucleus surrounded by symmetrical nebulosity, which gave the comet the appearance of a nebulous star. The extreme diameter of the nebulosity measured 39 seconds of arc, and the diameter of the nucleus measured 14 seconds. The nucleus and the nebulosity had not well-defined boundaries, but one shaded into the other imperceptibly.

On January 20 another photograph was taken with an exposure of 50 minutes, and on this also the comet appears like a large nebulous star, the extreme diameter of which measured 145 seconds of arc, and the diameter of the nucleus 53 seconds. The nucleus and the nebulosity surrounding it are very dense and symmetrically circular, without sharply defined boundaries.

On January 27 another photograph was taken, with exposure of 15 minutes, upon which the comet appears with a faint nucleus, a faint tail, and very faint nebulosity surrounding them, much like the form shown on the photograph presented to the Society at the meeting in December last.

On February 4 another photograph was taken, with exposure of 52 minutes, and the appearance of the comet very strongly resembled that referred to in the foregoing paragraph—it had a nucleus, a tail, and faint nebulosity surrounding them; much like those shown on the photograph presented in December.

The negatives do not indicate any stars or nebulæ on the orbital course of the comet that might temporarily add to its brightness when in transit over them, but whatever the cause may have been, the reality of the phenomena can scarcely be doubted, for both eye-observations and the photographs confirm each other.

On the Orbit of Σ 1785. By J. E. Gore.

Using the measures of this binary pair given by Mr. Burnham in the *Monthly Notices* for 1892 December, I have computed the orbit, and find the following provisional elements —

Elements of Σ 1785.

P = 125·52 years	Ω = 137° 1′
T = 1904·84	λ = 220° 21′
e = 0·6377	a = 2″·18
i = 34° 46′	μ = +2°·868

The following is a comparison between the measures and the positions computed from the above elements:—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
		°	°	°	″	″	″
1823·40	South	160·4	157·3	+3·1	5·66	3·25	(+2·41)
1830·12	Struve	164·4	162·7	+1·7	3·49	3·33	+0·16
1830·20	Herschel	164·5	162·8	+1·7	4·62	3·33	(+1·29)
1831·34	Herschel	166·3	163·6	+2·7	(7·69)	3·38	(+4·31)
1843·48	Mädler	174·6	173·0	+1·6	3·39	3·30	+0·09
1846·40	Philpott	176·2	175·3	+0·9	3·19	3·26	−0·07
1850·44	Mädler	178·0	178·7	−0·7	...	3·18	...
1851·28	Mädler	178·7	179·4	−0·7	3·48	3·16	+0·32
1855·32	Mädler	183·6	182·9	+0·7	3·11	3·08	+0·03
1856·31	Mädler	183·1	184·0	−0·9	2·97	3·05	−0·08
1856·36	Secchi	186·0	184·0	+2·0	3·24	3·05	+0·19
1858·38	Dembowski	185·1	185·8	−0·7	3·12	3·05	+0·12
1859·32	Morton	185·4	186·7	−1·3	2·89	2·97	−0·08
1861·57	Mädler	190·0	188·9	+1·1	3·51	2·90	+0·61
1863·31	Radcliffe	192·0	190·7	+1·3	2·73	2·83	−0·10
1863·68	Dembowski	191·1	191·1	0·0	2·66	2·82	−0·16
1864·47	Engelmann	193·5	192·0	+1·5	2·88	2·80	+0·08
1865·42	Engelmann	193·8	193·0	+0·8	2·87	2·77	+0·10

Epoch.	Observer.	θ_o	θ_c	$\theta_o-\theta_c$	ρ_o	ρ_c	$\rho_o-\rho_c$
		°	°	°	"	"	"
1865·82	Dembowski	193·3	193·5	−0·2	2·59	2·75	−0·16
1867·40	O. Struve	196·1	195·3	+0·8	2·81	2·70	+0·11
1867·83	Dembowski	195·8	195·8	0·0	2·52	2·68	−0·16
1870·19	Dunér	198·6	198·8	−0·2	2·54	2·57	−0·03
1870·33	O. Struve	199·4	199·0	+0·4	2·79	2·57	+0·22
1870·35	Gledhill	200·5	199·0	+1·5	2·54	2·57	−0·03
1870·81	Dembowski	199·4	199·6	−0·2	2·43	2·55	−0·12
1871·35	Radcliffe	199·1	200·3	−1·2	2·43	2·53	−0·10
1871·38	Knott	199·2	200·3	−1·1	2·51	2·53	−0·02
1871·43	Pierce	199·9	200·4	−0·5	2·38	2·53	−0·15
1872·43	Dunér	201·7	201·7	0·0	2·67	2·49	+0·18
1872·89	Dembowski	201·9	202·3	−0·4	2·32	2·47	−0·15
1873·42	Linstedt	200·2	203·1	−2·9	2·41	2·45	−0·04
1873·57	Wilson & Seabroke	202·2	203·3	−1·1	2·45	2·44	+0·01
1874·79	Dembowski	205·2	205·1	+0·1	2·18	2·37	−0·19
1875·24	Dunér	206·4	205·8	+0·6	2·47	2·35	+0·12
1875·32	Schiaparelli	205·3	205·9	−0·6	2·34	2·34	0·00
1876·00	Wilson & Seabroke	207·6	206·9	+0·7	2·37	2·30	+0·07
1876·41	Plummer	208·6	207·5	+1·1	2·56	2·28	+0·28
1876·45	Schiaparelli	206·9	207·6	−0·7	2·15	2·28	−0·13
1876·85	Dembowski	208·5	208·2	+0·3	2·14	2·26	−0·12
1877·32	Doberck	208·4	209·1	−0·7	2·21	2·24	−0·03
1877·38	Schiaparelli	208·6	209·2	−0·6	2·25	2·24	+0·01
1878·34	Dembowski	210·5	210·9	−0·4	2·14	2·21	−0·07
1878·39	Seabroke	210·7	211·0	−0·3	2·55	2·21	+0·34
1879·42	Hall	214·5	212·8	+1·7	2·04	2·16	−0·12
1879·46	Schiaparelli	212·5	212·9	−0·4	2·20	2·16	+0·04
1879·50	Seabroke	214·0	213·0	+1·0	2·07	2·16	−0·09
1880·35	Hall	215·9	214·5	+1·4	1·92	(2·12)	−0·20
1880·37	Bigourdan	213·8	214·6	−0·8	2·13	2·11	+0·02
1880·46	Jedrzejewicz	215·4	214·7	+0·7	2·27	2·11	+0·16
1880·46	Seabroke	215·2	214·7	+0·5	2·03	2·11	−0·08
1881·33	Bigourdan	216·9	216·5	+0·4	1·98	2·05	−0·07
1881·36	Schiaparelli	217·9	216·6	+1·3	2·11	2·05	+0·06
1881·40	Hough	215·7	216·6	−0·9	1·96	2·05	−0·09
1881·40	Hall	217·8	216·6	+1·2	1·92	2·05	−0·13
1882·42	Hall	219·9	218·8	+1·1	1·93	2·00	−0·07
1882·44	Schiaparelli	220·0	218·9	+1·1	2·13	2·00	+0·13
1882·45	Seabroke	221·3	218·9	+2·4	2·22	2·00	+0·22

Epoch.	Observer.	θ_o	θ_c	$\theta_o-\theta_c$	ρ_o	ρ_c	$\rho_o-\rho_c$
		°	°	°	"	"	"
1882·46	Rugby	221·9	218·9	+3·0	2·22	2·00	+0·22
1882·93	Engelmann	221·2	219·9	+1·3	2·06	1·97	+0·09
1883·42	Hall	221·6	221·0	+0·6	1·90	1·94	−0·04
1883·46	Schiaparelli	221·8	221·1	+0·7	1·91	1·94	−0·03
1884·39	Hall	224·8	223·3	+1·5	1·86	1·89	−0·03
1884·46	Schiaparelli	224·9	223·5	+1·4	1·98	1·89	+0·09
1884·63	Rugby	226·6	223·9	+2·7	1·78	1·88	−0·10
1885·35	Perrotin	223·8	225·7	−1·9	1·86	1·84	+0·02
1885·36	Hall	226·8	225·7	+1·1	1·78	1·84	−0·06
1885·43	Rugby	227·9	225·9	+2·0	1·72	1·84	−0·12
1885·44	Schiaparelli	227·1	225·9	+1·2	1·83	1·84	−0·01
1886·38	Perrotin	228·7	228·4	+0·3	1·68	1·79	−0·11
1886·41	Rugby	231·4	228·5	+2·9	1·46	1·79	−0·33
1886·41	Hall	228·0	228·5	−0·5	1·83	1·79	+0·04
1887·37	Hall	232·7	231·3	+1·4	1·62	1·73	−0·11
1887·45	Schiaparelli	231·8	231·5	+0·3	1·67	1·73	−0·06
1887·45	Rugby	232·8	231·5	+1·3	1·08	1·73	−0·65
1887·59	Tarrant	228·0	231·9	−3·9	1·80	1·72	+0·08
1888·33	Rugby	236·5	234·1	+2·4	1·12	1·67	−0·55
1888·37	Hall	233·9	234·2	−0·3	1·61	1·67	−0·06
1889·28	Rugby	235·3	237·1	−1·8	1·60	1·61	−0·01
1889·45	Hall	237·1	237·7	−0·6	1·51	1·61	−0·10
1890·43	Hall	240·7	241·1	−0·4	1·54	1·54	0·00
1890·47	Hayn	240·5	241·2	−0·7	1·57	1·54	+0·03
1892·37	Burnham	248·6	248·6	0·0	1·46	1·43	+0·03

As the great majority of the residuals in position-angle are less than 2°, and many under 1°, the agreement may be considered satisfactory.

Assuming that the mass of the system is equal to the mass of the Sun, the "hypothetical parallax" will be—

$$p = aP^{-\frac{2}{3}} = 0''{\cdot}087.$$

On the Orbit of the Binary Star β 416. By J. E. Gore.

This star, which is identical with BAC 5825, was discovered as a wide double star by Sir John Herschel on 1837 June 8, during his residence at the Cape of Good Hope. In 1876 Mr. Burnham found the brighter component to be also double, but only estimated the position-angle and distance. Since its

discovery the star has not been often measured, there being no measures in the years 1877–88. I find, however, that the available measures, although few in number, are sufficient to give an approximate orbit, the change in position-angle since 1876 being over 200°. I have therefore computed the orbit, and find the following provisional elements:—

Elements of β 416.

P = 34·48 years	Ω = 139° 26′
T = 1891·85	λ = 278° 15′
e = 0·5562	a = 2″·13
i = 56° 43′·5	μ = −10°·4413

The following is a comparison between the measures and the positions computed from the above elements:—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \vartheta_o$	ρ_o	ρ	$\rho_o - \rho_c$
1876·52	Burnham	240° ±	231°·6	+8°·4	1″·80 ±	1″·81	−0″·01 ±
1877·53	At Cincinnati	222·6	225·1	−2·5	1·80	1·79	+0·01
1877·64	Russell	224·4	224·4	0·0	1·77	1·78	−0·01
1888·72	Burnham	147·5	146·8	+0·7	1·88	1·52	+0·36
1889·43	„	134·1	139·3	−5·2	1·35	1·36	−0·01
1889·63	Pollock	131·9	136·9	−5·0	0·97	1·30	−0·33
1891·53	Burnham	82·3	86·1	−3·8	0·51	0·60	−0·09
1892·38	„	24·4	24·3	+0·1	0·58	0·57	+0·01

The measure in 1892, made with the 36-inch refractor of the Lick Observatory, was kindly sent to me by Mr. Burnham.

Assuming the mass of the system to be equal to the mass of the Sun, the "hypothetical parallax" will be—

$$p = \frac{a}{P^{\frac{2}{3}}} = 0''\cdot201.$$

The magnitudes of the components are about 6·3, and 8. As a single star it was estimated 6·1 at Cordoba (142 Scorpii, U.A. =Lacaille 7215).

The position of the star is for 1880—

R.A. $17^h\ 10^m\ 47^s$

Decl. −34° 51′ 12″

Mr. Burnham measured the distant companion as follows:—

1892·36 : 129°·4 : 30″·55 ; mag. 12.

As Sir John Herschel estimated the position-angle at 130°±, there would seem to be no change in the position of this companion.

On certain Variable Stars having the Appearance, visually, of Planetary Nebulæ. By Cuthbert E. Peek, M.A.

Having observed variable stars regularly for the last seven years, I wish to call attention to a letter published in *Knowledge* 1892 March 1, in which I refer to the fact that a considerable number have, at times, the appearance of planetary nebulæ as described by Herr E. von Gothard in the January number of the *Monthly Notices*. Without repeating the whole of the facts there given, I quote the following with regard to three stars:—

R. Cassiopeiæ, 1886 September 17, 8·7 mag.—A large, ill-defined, deep-red star. 1889 March 11, 9·6 mag. Very hazy and ill-defined, as if shining through ruddy mist. Other stars sharp.

T. Cassiopeiæ, 1889 September 10, 7·7 mag.—Very red. A well-defined star shining through a ruddy haze.

S. Herculis, 1891 October 14.—With power 132 a faint nebulosity is suspected in the place of the variable; on slightly swaying the telescope a bluish nebulosity is certainly seen. It will be remembered that *Nova Aurigæ* was first described in the *Times* of 1892 February 3 as 'slightly fuzzy.' Instrument in use 6¼-inch equatoreal refractor.

Rousdon Observatory:
1892 *January* 29.

Observations of Saturn in 1892. By M. Joseph Guillaume, of the Observatoire de Lyon.

(*Communicated by the Rev. A. Freeman.*)

The following is the translation of a letter received by Mr. Freeman from M. Guillaume, 1893 January 5.

"I must first of all tell you that I left my own observatory at Péronnas (near Bourg-en-Bresse) in September last for that of Lyons, where I am working under the direction of M. Ch. André.

"I have published nothing as yet upon *Saturn* in 1892, but I proceed to give you all that I could say about the planet, leaving it to you to communicate it to the Royal Astronomical Society in part or entirely as may appear best to you.

"A long course of bad weather at the beginning of the year hindered me from observing as much as I could have desired, especially in watching the transits of the satellites other than

Titan, to which M. Terby has particularly drawn my attention. I have made only seventeen observations, which may be described thus:—

"The northern hemisphere continued to appear more dusky than the other. I noticed on it a broad bright band, which appeared striated on March 23. It was separated from a broader grey zone by a dusky narrow band sometimes stippled; and then, towards the north, another band of a deeper tint a little broader than the first band. These two bands were not always easy to limit internally. The polar cap has not always shown the same appearance; thus, when the details which I have mentioned were visible its aspect was less sombre; otherwise, although less deep in tint, there was never any sharp boundary between this region and the broad grey zone.

"On the south hemisphere the appearance was sensibly the same as in 1891. The equatorial band displayed brighter parts than the rest on March 11, and the rest of the hemisphere exhibited marblings; but on April 15, with a remarkably fine image, I saw the first dark band divided by a narrow bright line, very faint, and then two bright bands separated by a grey one of the same appearance as the polar cap.

"Apart from the variations of brightness remarked upon the two ansæ, there were few details to note upon the rings on account of their small opening. Sometimes the dark ring was perceived, and the Cassini division, always bordered externally by a bright zone similar to the ring *B*. On March 11 the ring *C* was visible, in front of the ball, at the same time with a narrow black line, which might be the shadow of the rings. *A* was grey at the ends of the ansæ. On March 31 the middle of *B* at the west was grey. Later, the ring closing up, I could only notice the difference of brightness, which I continued to register by schematic figures. On May 21, the last observation made, an interval between the ball and the ring appeared to a slight extent on the east. The western ansa [*eastern* is meant], after the opposition, appeared to me thinner against the ball than on the opposite side, which was evidently due to the shadow projected by the planet. On April 15 it even appeared separated from the ball with a magnifying power of 194, but with 298 there was no solution of continuity; the ring was only thinner.

"The shadow of the ring has sometimes been noticed oppositely curved relatively to the ring; it has exhibited variations of extent, produced by the differing inclinations of the Sun and the Earth to the plane of the rings.

"*The Satellites.*—I observed the shadow of *Titan* upon the ball on February 24; the satellite was dusky and greenish-yellow rather than orange-rose, as it appeared to me on 1891 December 23; it was very near the planet on the east; it must have passed in front very near the limb, but the clouds prevented me from following it. On March 11 an observation, short on account of the clouds, permitted me to see *Titan* and his shadow

near each other; the satellite was a little more south than the shadow, and very dark, almost black. On April 28 the clouds prevented me from seeing the passage before the ball, but a little later *Titan* travelled a very short distance to the south of the ring. I regretted having been unable to follow the transit, because *Titan* must have passed along the shadow of the ring. *Titan* appeared to me bluish-green, and of brightness sensibly equal to that of the ring. On May 6, from $8^h\ 10^m$ to $8^h\ 20^m$ [Paris M.T.], *Titan* was not visible; if it did not travel just behind the ring, which the state of the telescopic image prevented me from seeing, it was occulted. On May 14 I at first noticed this satellite in front of the ring as a luminous spot; then, towards the end of its passage, the instant of separation from the ring was not easy to determine precisely. At the beginning of the observation I believed I saw an indentation on the south border of the east ansa, which might be the shadow of *Titan*, but the view was not perfect enough for me to be absolutely sure of this appearance, which was of short duration.

"I several times attempted to observe the passage of the other satellites. Unfortunately the atmospheric conditions always left much to be desired, and my efforts to observe anything have met with no success. On April 15 the view, however, was such *at instants* that I do not think it possible to have a better; yet, in spite of all my attention, I was not able to observe the transit of *Rhea*; and, at the moment, I concluded that the phenomena of this satellite, and, for the greater reason, of the smaller satellites, could not be observed except with an instrument more powerful than my excellent reflector of 216 millimetres diameter ($8\frac{1}{2}$ ins.), the mirror by With."

Observations of the Position-Angle of the Ring of Saturn.

By A. Stanley Williams.

The following measures of the position-angle of the major axis of the ring of *Saturn* were made with a $6\frac{1}{2}$-inch reflector by Calver. The position micrometer is a small one by Troughton & Simms. The position circle, $2\frac{1}{2}$ inches in diameter, is divided to 30′, and reads by a single vernier to 1′. The magnifying power used was 230. Prior to April 22 a single thin wire was employed, but, owing to the increasing narrowness of the ring, this became unsatisfactory, and the subsequent measures were made by separating the distance-webs to a distance of about 4″, and bringing the ring between them.

Date.	G.M.T.	Observed. p	Marth. p	Δp
1891.	h m	°	°	°
Dec. 20	16 57	85·75 (8)	85·99	+0·24
21	15 53	86·03 (5)	85·99	−0·04
22	16 38	85·80 (6)	85·99	+0·19
1892.				
Jan. 1	14 47	86·05 (6)	86·02	−0·03
4	16 5	85·70 (8)	86 02	+0·32
Mar. 18	10 23	85·52 (6)	85·72	+0·20
Apr. 1	9 55	85·26 (8)	85·63	+0·37
4	9 52	85·47 (8)	85·61	+0·14
17	12 28	85·50 (8)	85·54	+0·04
22	9 48	85·75 (8)	85·52	−0·23
23	9 54	85·50 (5)	85·51	+0·01
May 6	11 9	85·67 (8)	85·46	−0·21
8	9 45	85·74 (8)	85·46	−0·28
30	9 48	84·99 (12)	85·44	+0·45
June 6	9 37	85·34 (8)	85·44	+0·10
7	9 31	85·67 (8)	85·45	−0·22
			Mean =	+0·07

The figures in brackets after the observed position-angles indicate the number of settings. In the fourth column are given the position-angles of the axis of *Saturn* according to Mr. Marth's "Ephemerides of the Satellites of *Saturn*, 1891–1892," less 270°. In other words, they are the position-angles of the major axis of the narrow apparent ellipse formed by the planet's equator; and, assuming the plane of the ring to coincide with the plane of the equator, they would likewise be the computed position-angles of the major axis of the ring.

The mean value of the residuals Δp is $+3'\cdot96$, with a probable error of $\pm 2'\cdot29$; the probable error of a single observation being $\pm 9'\cdot12$. The telescope is equatorially mounted, but without clockwork. The major axis of the ring was, however, so little inclined to a parallel of declination, that the latter deficiency has probably had little or no effect on the accuracy of the measures. At any rate, judging from the above values of the probable errors, these observations appear comparable in point of accuracy with those made by other observers.

Brighton:
1893 *February* 24.

Observations of Mars and ι Aquarii near their conjunction on 1892 November 4. By John Tebbutt.

The actual conjunction of *Mars* and *ι Aquarii* occurred rather too early for observation in this meridian, but it was quite obvious that an occultation could not have taken place. The star is No. 163 of Herr Berberich's list in No. 3,073 of the *Astronomische Nachrichten*. Two sets of ten fairly good comparisons were obtained of the planet and star with the filar micrometer of the 8-inch equatoreal. In all twenty comparisons the planet's preceding limb was observed for right ascension, but in the first set the north and in the second the south limb was observed for declination. The following are the results, the corrections for chronometer rate and refraction being insensible. The star's mean place is derived from the Greenwich Catalogues for 1872 and 1880, the result from each catalogue being weighted according to the number of individual observations on which it is founded.

	First Set.	Second Set.
	h m s	h m s
Windsor mean time of transit of Planet's limb	8 1 57·1	8 15 45·6
Star's adopted mean R.A. for 1892·0	22 0 36·21	22 0 36·21
Reduction	+2·46	+2·46
Observed Diff. R.A. of Limb and Star ...	+7·90	+8·97
Correction for Semidiameter	+0·50	+0·50
Correction for Parallax	+0·16	+0·20
Resulting Geocentric R.A. of Planet's centre ...	22 0 47·23	22 0 48·34
Geocentric R.A. of Centre from *Nautical Almanac*	22 0 47·23	22 0 48·41
Observation—*Nautical Almanac*	0·00	−0·07
	° ′ ″	° ′ ″
Star's adopted Mean Declination for 1892·0	−14 23 35·9	−14 23 35·9
Reduction	+8·2	+8·2
Observed Diff. Declination of Limb and Star ...	−1·1	−5·7
Correction for Semidiameter	−7·2	+7·2
Correction for Parallax	−3·8	−3·8
Resulting Geocentric Declination of Planet's centre	−14 23 39·8	−14 23 30·0
Geocentric Declination of Centre from *Nautical Almanac*	−14 23 38·7	−14 23 30·7
Observation—*Nautical Almanac*	−1·1	+0

The Occultation of Jupiter, 1893 *February* 20.

By C. Leeson Prince.

The weather was most unfavourable for observing this phenomenon, but through breaks in the clouds I was able to watch the gradual approach of the Moon towards the planet. Observation of first contact was prevented by a large mass of cloud, and when this cleared off the planet was very nearly occulted; but I was able to see the final disappearance, which happened at $0^h\ 33^m\ 31^s$, L.S.T., but upwards of 14 minutes later than the time given in the *Nautical Almanac*. The atmosphere was in a too tremulous condition to observe whether there was any distortion of the planet's limb or any shaded line upon it.

I had no further opportunity for observation until $1^h\ 45^m\ 15^s$, when the following limb of the planet was $8^m\ 30^s$ west of the Moon. I consider my new observatory to be 39 seconds east of Greenwich. Telescope is of 6·8 inches' aperture and 12-feet focal length. Power 80.

The Observatory, Crowborough, Sussex:
1893 *February*.

Observations of Brooks' Comet (g 1892) and Holmes' Comet (f 1892) made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East, or Sheepshanks, Equatorial, aperture 6·7 inches, by taking transits over two cross wires at right angles to one another, and each inclined 45° to the parallel of declination. Transits were sometimes taken also over a third wire bisecting the angle between the two other wires. Magnifying power, 55.

Brooks' Comet.

Greenwich Mean Solar Time.					Observer.	♂−✱ R.A.	Corr. for Refraction.	Corr. for Motion of ♂	Log. factor of Parallax.	♂−✱ N.P.D.	Corr. for Refraction.	Corr. for Motion of ♂	Log. factor of Parallax.	No. of Comps.	Apparent R.A.	Apparent N.P.D.	Comp. Star.
1893.	d	h	m	s		m s	s	s		′ ″	″	″			h m s	° ′ ″	
Jan.	10	8	36	30	H.	−2 14·00	+0·04	−0·45	9·8843	+15 51·6	+0·3	−5·7	0·6373	3	20 59 37·02	27 18 36·4	*a*
	10	9	1	34	,,	−0 12 98	+0·01	−0·51	9·8742	+4 32·3	+0·1	−6·4	0·6921	2	21 0 0·06	27 19 43·6	*b*
	15	7	44	7	,,	+1 21·55	+0·03	−0·31	9·7958	+12 46·1	0·0	−2·5	0·4529	3	22 20 24·35	34 47 21·5	*c*
	15	8	20	34	,,	−0 53·30	0·00	+0·17	9·8080	− 2 24·5	−0·1	+1·3	0·5537	2	22 20 43·58	34 49 23·1	*d*
	20	10	6	19	A. C.	−0 6·43	−0·01	−0·09	9·7212	+ 8 26·8	+0·2	−0·6	0·7596	2	...	...	*e*
	20	10	15	45	,,	−0 12·03	+0·01	+0·11	9·7154	− 5 47·7	−0·2	+0·9	0·7720	4	...	...	*f*
Feb.	4	6	51	21	,,	+0 4·10	0·00	+0·06	9·5697	− 3 27·6	0·0	+0·5	0·6185	2	0 1 10·24	56 52 58·8	*g*
	4	6	55	37	B.	+0 3·03	0·00	+0·06	9·5750	− 3 39·4	0·0	+0·5	0·6237	3	0 1 9·17	56 52 47·0	*g*
	5	6	45	16	,,	−1 3·70	0·00	+0·03	9·5625	+ 0 20·3	0·0	+0·3	0·6213	2	...	...	*h*
	5	6	52	4	A. C.	−1 [illegible]·3	0·00	+0·03	9·5700	+ 0 30·0	0·0	+0·3	0·6284	4	...	...	*h*
	5	6	55	0	,,	−1 35·66	0·00	+0·03	9·5732	+ 5 15·0	0·0	+0·3	0·6315	1	...	...	*i*
	8	6	51	42	B.	−0 6·18	0·00	−0·03	9·5678	+ 2 12·0	0·0	−0·3	0·6544	3	0 9 26·58	59 22 1·4	*j*
	10	7	13	45	,,	+0 55·09	0·00	−0·03	9·5925	+ 0 34·4	0·0	−0·3	0·6869	2	...	...	*k*
	16	6	41	23	,,	−0 27·56	0·00	+0·02	9·5603	− 6 26·5	−0·1	+0·2	0·6966	3	...	...	*l*

Holmes' Comet.

Greenwich Mean Solar Time.				Observer.	✐ − ✱ R.A.	Corr. for Refraction.	Corr. for Motion of ✐	Log. factor of Parallax.	✐ − ✱ N.P.D.	Corr. for Refraction.	Corr. for Motion of ✐	Log. factor of Parallax.	No. of Comps.	Apparent R.A.	Apparent N.P.D.	Comp. Star.
1893.	d	h m s			m s	s	s		′ ″	″	″			h m s	° ′ ″	
Jan.	20	9 27 41		A. C.	+2 14·93	0·00	0·00	9·5834	− 1 25·9	0·0	0·0	0·6268	2	1 27 1·98	56 21 7·7	*m*
	24	9 24 19		,,	+0 2·93	0·00	0·00	9·5931	+ 7 55·9	0·0	0·0	0·6348	3	1 32 33·74	56 19 33·5	*n*
	27	6 19 29		L.	+0 29·42	0·00	0·00	9·1330	+ 0 27·5	0·0	−0·2	0·4494	2	...	...	*o*
	27	6 28 27		A. C.	+0 30·08	0·00	0·00	9·1853	+ 0 27·2	0·0	0·0	0·4557	2	...	...	*o*
	27	6 33 2		B.	+0 28·64	0·00	0·00	9·2077	+ 0 39·0	0·0	0·0	0·4590	2	...	...	*o*
Feb.	4	7 9 34		,,	+0 58·91	0·00	0·00	9·4108	+ 6 12·4	0·0	−0·2	0·5075	3	1 48 25·93	56 7 49·9	*p*
	4	8 36 20		A. C.	+1 8·39	0·00	0·00	9·5716	+ 6 38·4	+0·1	−0·3	0·6084	4	1 48 35·41	56 8 15·9	*p*
	5	8 34 13		B.	−0 12·40	0·00	0·00	9·5718	− 1 31·3	0·0	+0·3	0·6080	3	...	...	*q*
	5	8 49 7		,,	+2 36·89	0·00	0·00	9·5888	+ 4 51·6	0·0	−0·2	0·6262	2	1 50 3·89	56 6 29·1	*p*
	5	9 42 12		A. C.	−2 33·20	0·00	0·00	9·6303	− 3 24·3	0·0	+0·2	0·6890	2	1 50 10·21	56 7 18·9	*r*
	6	6 42 56		B.	−1 16·31	0·00	0·00	9·3460	− 5 48·4	0·0	+0·2	0·4846	2	1 51 27·08	56 4 54·8	*r*
	6	7 14 24		T. H.	−1 12·45	0·00	0·00	9·4342	− 5 42·0	0·0	+0·3	0·5168	4	1 51 30·94	56 5 1·3	*r*
	7	8 12 19		H.	+0 24·96	0·00	0·00	9·5348	− 7 27·0	−0 1	+0·3	0·5870	5	1 53 8·34	56 3 16·4	*r*

Greenwich Mean Solar Time.				Observer.	α − ✱ R.A.	Corr. for Refraction.	Corr. for Motion of α	Log. factor of Parallax.	δ − ✱ N.P.D.	Corr. for Refraction.	Corr. for Motion of δ	Log. factor of Parallax.	No. of Comps.	Apparent R.A.	Apparent N.P.D.	Comp. Star.
1893.	d	h	m s		m s	s	s		′ ″	″	″			h m s	° ′ ″	
Feb.	8	7	6 17	B.	−0 31·59	0·00	0·00	9·4275	+ 2 56·6	0·0	0·0	0·5125	3	...	...	*s*
	8	7	24 9	,,	+1 53·40	0·00	0·00	9·4684	− 9 30·2	0·0	+0·3	0·5319	3	1 54 36·76	56 1 13·4	*r*
	10	7	34 59	,,	+0 11·24	0·00	0·00	9·5003	+ 0 1·5	0·0	+0·3	0·5492	3	...	...	*t*
	10	7	41 29	,,	+1 17·80	0·00	0·00	9·5127	+ 7 7·6	+0·1	−0·2	0·5572	2	1 57 44·26	55 58 17·0	*u*
	14	8	47 14	T. H.	+0 40·20	0·00	0·00	9·6082	+ 9 18·8	0·0	−0·4	0·6462	1	...	...	*v*
	15	9	45 32	H.	−1 11·73	0·00	0·00	9·6430	− 4 24·7	−0·1	−0·2	0·7173	2	...	...	*w*
	15	9	50 59	,,	−1 48·60	0·00	0·00	9·6440	− 4 4·2	−0·1	0·0	0·7233	5	2 5 51·75	55 48 31·7	*x*
	15	10	3 44	,,	−1 43·35	+0·01	0·00	9·6471	− 9 53·9	−0·3	+0·4	0·7375	2	2 5 52·47	55 49 5·8	*y*
	16	6	59 23	B.	−0 23·93	0·00	0·00	9·4567	− 6 17·2	0·0	+0·2	0·5206	3	2 7 16·40	55 46 19·1	*z*
	16	7	5 18	,,	−0 43·27	0·00	0·00	9·4699	+11 3·0	0·0	−0·4	0·5277	3	...	...	*z*

Notes.

The observations are corrected for refraction but not for parallax. They are also corrected for the error of inclination of the wires, and where necessary for the motion of the comets in R.A. and N.P.D.

On January 15 Brooks' Comet was very faint; no nucleus seen. On February 10 it was exceedingly faint and difficult to observe.

On January 20 Holmes' Comet was small and very bright, but it rapidly became fainter and more diffused.

Comparison Stars.

	Star's Name.	R.A., 1893·0. h m s	N.P.D., 1893·0. ° ′ ″	Authority.
a	B.D. + 62°, 1889	21 1 54·94	27 2 49·7	Astr. Gesell. Cat. (Helsingfors-Gotha, 1875)
b	B.D + 62°, 1885	21 0 17·03	27 15 17·0	„ „ „
c	Piazzi XXII., 92	22 19 5·79	34 34 41·3	Greenwich Observations, 1890.
d	B.D. + 54°, 2773	22 21 39·39	34 51 50·0	Astr. Gesell. Cat. (Helsingfors-Gotha, 1875)
e	B.D. + 47°, 4061	23 5 2	42 11	Equatorial comparisons with neighbouring stars.
f	B.D. + 47°, 4060	23 5 12	42 26	Bonn Observations, vol. v.
g	W.B. (2) XXIII., 1306	0 1 7·66	56 56 27·6	Paris Observations in 1862 and 1881.
h	Anonymous	0 4 14	57 28	Difference from Star *i*.
i	B.D. + 32°, 10	0 4 48	57 23	Bonn Observations, vol. iv.
j	B.D. + 30°, 27	0 9 34·33	59 19 50·6	„ „ vol. vi.
k	B.D. + 29°, 30	0 10 22	59 50	„ „ vol. iv.
l	B.D. + 26°, 62	0 22 56	63 19	„ „ „
m	Lalande, 2729	1 24 47·93	56 22 41·8	Paris Observations, 1881.
n	B.D. + 33°, 267	1 32 31·70	56 11 45·9	Bonn Observations, vol. vi.
o	B.D. + 33°, 282	1 36 9	56 16	„ „ vol. iv.
p	W.B. (2) I., 1047	1 47 27·99	56 1 45·8	Weisse's Bessel
q	B.D. + 33°, 325	1 50 19	56 8	Bonn Observations, vol. iv.
r	Lalande, 3619	1 52 44·36	56 10 51·1	Paris Observations, 1880.

	Star's Name.	R.A., 1893·0. h m s	N.P.D., 1893·0. ° ′ ″	Authority.
s	B.D. + 33°, 339	1 55 5	55 59	Bonn Observations, vol. iv.
t	B.D. + 33°, 353	1 57 32	55 57	,, ,, ,,
u	W.B. (2) I., 1292	1 56 27·47	55 51 17·5	Weisse's Bessel.
v	B.D. + 34°, 382	2 3 32	55 41	Bonn Observations, vol. iv.
w	B.D. + 33°, 381	2 7 3	55 52	,, ,, ,,
x	Lalande, 4092	2 7 41·37	55 52 44·0	Paris Observations, 1882.
y	Lalande, 4086	2 7 36·83	55 59 7·6	,, ,, ,,
z	B.D. + 34°, 396	2 8 1	55 36	Bonn Observations, vol. iv.

Note.

The place of star *e* in the B.D. reduced to 1893·0 (viz., R.A. $23^h\ 5^m\ 26^s$, N.P.D. 42° 10′) appears to be largely in error. The place given is derived from approximate equatorial comparisons with neighbouring stars.

The initials L., H., A. C., B., T. H., are those of Mr. Lewis, Mr. Hollis, Mr. Crommelin, Mr. Bryant, and Mr. Hudson respectively.

Erratum in '*Monthly Notices*,' liii. 3 (1893 *January*), *pp.* 134, 135.

Star *d* (Lalande 25647), N.P.D., *for* 57° 33′ 55″·0 *read* 57° 35′ 55″·0.
Corresponding N.P.D. of ☄, *for* 57° 40′ 11″·3 *read* 57° 42′ 11″·3.

Errata.

In Mr. Gledhill's paper, *Monthly Notices*, vol. liii. pp. 149, 150, the *observed* times should read $8^h\ 55^m$. &c., instead of $8^h{\cdot}55$. The *predicted* times, however, being quoted from Mr. Marth's Ephemeris, are given in decimals of an hour.

In the obituary of Prof. J. C. Adams, *Monthly Notices*, vol. liii. p. 201,

1st line from top, *for* 39′ *read* 29′; and
2nd „ „ *for* 23·25 *read* 33·25 years.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. APRIL 14, 1893. No. 6

Captain W. DE W. ABNEY, C.B., R.E., D.C.L., F.R.S., President, in the Chair.

Ludwig Becker, Ph.D., Professor of Astronomy and Director of the Observatory in the University of Glasgow;
Bernard Edward Cammell, Folly Court, Wokingham, Berks;
Raymond Hill Godfrey, F.R.G.S., 79 Cornhill, E.C., and Firview, Claygate, near Esher, Surrey;
Samuel Marcus Russell, Professor of Mathematics and Astronomy, Imperial College, Pekin, China,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers, from personal knowledge, being appended:—

Hedley Robert Beasley, Head Master of the Milldown School, Blandford, Dorset (proposed by Thomas Perkins);
Edwin Bailey Elliott, M.A., F.R.S., Waynfleete Professor of Pure Mathematics in the University of Oxford (proposed by E. J. Stone);
Walter Frederick Gale, M.R.S. of New South Wales, The Observatory, Paddington, New South Wales, Australia (proposed by H. C. Russell);
Arthur E. Kennelly, Edison's Laboratory, Orange, New Jersey, U.S.A. (proposed by D. J. Kennelly);
Arthur A. Rambaut, D.Sc., Royal Astronomer of Ireland, The Observatory, Dunsink, co. Dublin (proposed by Sir R. S. Ball);
Frederick Lumb Wanklyn, Grand Trunk Railway Company, Montreal, Canada (proposed by D. J. Kennelly).

Eighty-two presents were announced as having been received since the last meeting, including, amongst others :—

Agnes Giberne, Sun, Moon, and Stars (new edition), presented by the author ; Lick Observatory publications, No. 3 ; G. Levean, Théorie du mouvement de Vesta, presented by the author ; J. M. Schaeberle, Terrestrial atmospheric absorption of photographic rays of light, presented by the Observatory ; Original negatives of *Jupiter*, and photographs from drawings of *Mars*, presented by the Lick Observatory.

Reproduction of Photographs.

Arrangements have been made with Messrs. Eyre & Spottiswoode by which Fellows, and the public at large, will be able to obtain reproductions of photographs in the possession of the Society by purchase. Messrs. Eyre & Spottiswoode will copy such photographs, in every case providing one copy for the Society free of cost, and will sell copies to the Fellows or those who apply for them, at a fair price. It is to be understood that this firm has not been granted any exclusive right over the reproduction of photographs, and that the present arrangements are terminable at the pleasure of the Council.

The Council resolved, on 1893 April 14, that notice should be given to the Fellows of these arrangements by a paragraph in the *Monthly Notices*.

E. W. Maunder,
H. H. Turner,
Secretaries.

On the Parallactic Inequality in the Earth's Motion around the Sun. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

I take for the variations of the geocentric coordinates of the Sun due to a shift of origin from the common centre of gravity of the Earth and Moon to the centre of gravity of the Earth the expressions given by Le Verrier, *Solar Tables*, p. 47 :

$$dr = -\frac{m'}{m+m'} \cdot r' \cos s' \cdot \cos(\nu' - \nu).$$

$$\delta s = -\frac{m'}{m+m'} \frac{r'}{r} \cdot \sin s'.$$

$$dr = -\frac{m'}{m+m'} \frac{r'}{r} \cdot \cos s' \cdot \sin(\nu' - \nu).$$

where r' ν' s' are the geocentric coordinates of the Moon ; r ν the heliocentric coordinates of the Earth ; m' m the masses of the Moon and Sun. Putting $\nu = \odot + 180$, the expressions for $\odot$ and r are taken from Le Verrier's *Solar Tables*, pp. 52, 53, 54.

The coordinates of the Moon, V, U=s' and P, are taken from Delaunay's numerical results, *Conn. des Temps*, 1869. I put

$$\frac{m'}{m+m'}=\mu\,;\ \sin 1''\frac{a}{1}=\Pi\,;\ \sin 1''\frac{a}{r'}=\frac{P}{3422''\cdot7}\times C,$$

where a is the equatoreal radius of the Earth; π and C are the exact values of the constants of the Solar and Lunar Parallax; and $3422''\cdot7$ is the constant of lunar parallax adopted by Delaunay.

I then simply develop the expression

$$\frac{1}{r}\cdot\frac{3422''\cdot7}{P}\cos s',$$

which I find equals

$$\begin{aligned}0\cdot999547\,[1&-0\cdot0546\cos l-0\cdot0015\cos 2l\,.\,+0\cdot0020\cos 2F\\&-0\cdot0076\cos 2D-0\cdot0096\cos(2D-l),\\&-0\cdot0004\,.\,\cos(2D+l)+0\cdot0169\,.\,\cos l'+\&c.]\end{aligned}$$

Denoting $\nu'-\odot=V-\odot$ by A, and expressing $d\nu$ in seconds of arc, we have

$$\sin 1''d\nu''=\frac{\mu\cdot\Pi}{C}\times0\cdot999547\,[1-0\cdot0546\cos l-\&c.]\sin A.$$

If, therefore, we find from a discussion of observations that the coefficient of sin A is an angle α'', we have

$$\alpha''=\frac{\mu\,\Pi}{C\sin 1''}0\cdot999547,$$

and therefore, if we adopt for C the value $3422''\cdot7$, a value which appears to be one of considerable accuracy, we have

$$\Pi=\frac{\alpha''}{\mu}\cdot\frac{C\sin 1''}{0\cdot999547}=\frac{\alpha''}{\mu}\times0\cdot016601.$$

The factor 0·016601 agrees very closely indeed with Le Verrier's value 0·01662, which I verified and adopted in 1867 to deduce the value of the solar parallax from the angle $\alpha''=6''\cdot50$, a value which was found by Le Verrier from a discussion of observations of the Sun between 1804 and 1850, made at Greenwich, Paris, and Königsberg.

Some doubts have been expressed about the use by Le Verrier of the argument A=V−⊙ for the determination of the angle $6''\cdot50$. But Le Verrier states most clearly, on pages 47 and 48 of his *Solar Tables*, that r', ν', s', r, ν are the coordinates at the time; and he actually works out an example of the use of his formulæ for 1847 April 8, mean noon, in which the true longitudes and not the mean longitudes are carefully used.

He employs for the determination of the solar parallax the factor which would be the correct factor if his coefficient was determined strictly in accordance with his formula; and after

he has obtained the coefficient 6·50 he tabulates it for his *Solar Tables*, from an expression which is sensibly the same as that which I have found. (See pages 108, 109).

$$dv'' = 6''{\cdot}50 \sin A - 6''{\cdot}50[0{\cdot}0546 \cdot \cos l + 0{\cdot}015 \cos 2l + 0.0076 \cos 2D + 0{\cdot}0096 \cos (2D - l) + \&c.] \sin A + 6''{\cdot}50 \sin A \times 0{\cdot}0169 \cos l' + 6''{\cdot}50 \cdot \sin A \cdot \cos 2F^*$$

and in tabulating the results for his *Solar Tables* Le Verrier most carefully allows for the difference between $A = V - \odot$ and D, or for the difference between the true and mean longitudes of the Moon and Sun.

It is incredible to me that Le Verrier should have taken all the necessary precautions in working out an example of the use of the formulæ and in tabulating the results; should have selected a factor which is the proper one when the true longitudes are used and for cos s' the mean value 0·99867 is substituted; and yet should have neglected the precautions necessary to obtain an accurate value of the angle from a discussion of such an extended series of observations as that employed for the direct object of a determination of the value of the solar parallax.

I have also developed the expression for sin A, and have thus been led to the expression

$$dv = \frac{\mu\pi}{\sin 1'' \cdot C} 1{\cdot}004451 \left[\begin{array}{l} \sin D + 0{\cdot}0024 \sin 3D \\ -0{\cdot}0662 \sin (D - l) + 0{\cdot}0278 \sin (D + l) \\ +0{\cdot}0060 \sin (3D - l) \\ +0{\cdot}0272 \sin (D - l') \\ -0{\cdot}0101 \sin (D + l') \\ +0{\cdot}0021 \sin (D - 2F). \end{array}\right]$$

In this case, if β is the angle found from a discussion of observations as the coefficient of sin D, we shall have

$$\pi = \frac{\beta}{\mu} \cdot \frac{C \sin 1''}{1{\cdot}004451};$$

or, adopting as before, C = 3422·7, we have

$$\pi = \frac{\beta}{\mu} \times 0{\cdot}01652,$$

a result which agrees very closely indeed with that which Professor Newcomb has obtained when β is supposed to be the coefficient of the term sin D.

My result, however, differs from that obtained by Professor Newcomb with respect to the term +0·0021 sin (D − 2F), in the place of which Professor Newcomb has a term − 0·0020 sin 2F. I will, however, re-examine my work on this point; but I believe it to be correct.

* This term is not included in Le Verrier's expression.

It need hardly be pointed out that the angles α and β are not identical; and that the use of the factor 0·01652 with the angle α or the factor 0·01660 with the angle β will lead to sensibly erroneous values in the solar parallax.

The coefficients α or β will not however be obtained with accuracy from observations extending over periods of only two or three lunations, unless the periodical inequalities are accurately computed for the times of observation. The use of tabular places of the Sun, computed for intervals of a few days and then interpolated for the time of observation, will not in such cases be sufficient to secure accuracy.

The Secular Perturbations of the Earth arising from the Action of Venus. By R. T. A. Innes.

Although the eccentricities of the Earth and *Venus* are very small, the perturbing function is but slowly convergent on account of the high ratio of their mean distances.

Thus if the secular portion of the perturbing function be represented by

$$M e^h e^h n^f \cos A,$$

as in Le Verrier (*Annales*, tome ii. p. 89), the largest coefficient M is in the case of

Second power =	3·2	Le Verrier
Fourth power =	96·9	
Sixth power =	4710·0	

I therefore undertook the computation of the secular terms by Gauss's method, as laid down by Professor Hill. The elements used are found in Hill's "Jupiter and Saturn." The mass of *Venus* is assumed $\frac{1}{408134}$, and I get the following results. For comparison I add the figures found by Le Verrier and Hill by algebraical expansion, reducing all results to the above mass.

		Le V.	Hill.
	"	"	"
$\frac{de}{dt}$ =	+ 0·013156	+ 0·013440	
$e\frac{d\varpi}{dt}$ =	+ 0·057915	+ 0·057963	
$\frac{dp}{dt}$ =	+ 0·074459	+ 0·074504	+ 0·074433
$\frac{dq}{dt}$ =	− 0·284623	− 0·284538	− 0·284528
$\frac{dl}{dt}$ =	+ 11·232490	+ 11·229806	

So that my computation may be verified or corrected, I give the most important figures involved:—

$$K = 330^\circ\ 56'\ 48''.79 \qquad \log k = 9.9994999$$
$$K_1 = 330\ 51\ 5.11 \qquad \log k_1 = 9.9997387$$

Dividing the circumference into 12 parts, the sums of functions for 0°, 60°, 120°, 180°, 240°, 300°, and 30°, 90°, 150°, 210°, 270°, 330°, are equal to each other, and for A, B, and $\frac{r^2}{a^2}$, they are as follows:—

$$\frac{r^2}{a^2} = 6 + 3e^2 \qquad \frac{A}{a^2} = 6 + 3e^2 + 6\left[\left(\frac{a_1}{a}\right)^2 - 2k\left(\frac{a_1}{a}\right)ee_1 \cos K\right]$$
$$\frac{B\cos\epsilon}{a^2} = 6\left[\left(\frac{a_1}{a}\right)^2 e_1 - ke\frac{a_1}{a}\cos K\right] \qquad \frac{B\sin\epsilon}{a^2} = -6\left[k_1\left(\frac{a_1}{a}\right)\cos\phi_1 e\sin K_1\right]$$

These tests were satisfied.

From a manuscript table I took the values of

$$M = \frac{\sin\left(60^\circ - \frac{\theta}{3}\right) - v_1}{\frac{3}{2}\sqrt{12}} \text{ and } N = \frac{\frac{1}{2} + m^2 n^2 - v_1 \sin\theta}{\sin\left(60^\circ - \frac{\theta}{3}\right) - v_1}$$

To make these equal to Hill's functions, $\chi(r)$ and $\psi(r)$, it is necessary to multiply each by

$$\left[\frac{\cos\left(60 - \frac{\theta}{3}\right)}{\cos\theta}\right]^2$$

and N by M in addition. Instead of Hill's F, I computed Fq. In F_3 and J_3, I removed the common factor sin I, and in

$$\frac{a}{r}R \text{ \&c.}$$

the common factor

$$\left(\frac{a_1}{a}\right)^2 \cos^2\phi_1$$

to the end of the calculation, so that I could write

$$\frac{a}{r}R_0 = \left(\frac{r}{a}\right)\left(\frac{q}{a^2}\right)^{-\frac{7}{3}} M\left[\frac{\cos\left(60 - \frac{\theta}{3}\right)}{\cos\theta}\right]^2 \{F_1 + J_1(p + qN)\}.$$

These changes are very simple, thus:—

$$\left[\frac{dp}{dt}\right]_{00} = \frac{m_1 n}{1+m}\left(\frac{a_1}{a}\right)^2 \cos^2\phi_1 \sin I\left[\left(\tfrac{1}{2}C_1^{(c)} - \sin\phi\, C_0^{(c)}\right)\sec\phi \sin\varpi + \tfrac{1}{2}C_1^{(c)}\cos\varpi\right].$$

The portion of the table used for *Venus* and the Earth to find M and N is as follows:—

θ	Log M	θ	Log N
°		°	
1	9·5237699	1	0·1005869
2	9·5229823	2	0·0995895
3	9·5221837	3	0·0985821
4	9·5213742	4	0·0975647
5	9·5205536	5	0·0965374
6	9·5197219	6	0·0954999
7	9·5188789	7	0·0944526
8	9·5180245	8	0·0933955

I then have

	p		q^2	
1	0·4994744	0·5013630	0·0795055	0·0807033
2	0·5049397	0·5092804	826279	846595
3	0·5132391	0·5157380	863402	874101
4	0·5160732	0·5141376	876857	870065
5	0·5104671	0·5060796	853658	830996
6	0·5021677	0·4997626	809004	795465
S	3·0463612	3·0463612	0·5024255	0·5024255

	r		θ	
			° ′ ″	° ′ ″
1	0·0027381	0·0023201	+7 0 56·27	5 48 28·91
2	17893	13770	4 19 13·91	3 12 16·27
3	11341	9732	2 33 43·22	2 9 29·48
4	8465	8529	1 52 5·60	1 54 16·48
5	11449	17300	2 37 51·43	4 8 28·74
6	23844	27841	5 56 51·88	7 7 42·62
S	0·0100373	0·0100373	24 20 42·31	24 20 42·50

	F_1		F_2	
1	0·3248737	0·3261975	+0·0023649	−0·0001134
2	0·3293982	0·3339299	−0·0025722	−0·0043526
3	0·3384543	0·3413239	−0·0049775	−0·0042795
4	0·3414583	0·3389450	−0·0024456	+0·0000327
5	0·3348929	0·3306994	+0·0024915	+0·0042719
6	0·3273643	0·3253460	+0·0048968	+0·0041988
S	1·9964417	1·9964417	−0·0002421	−0·0002421

	F_2		Log J_2	
1	+0·0021106	−0·0000634	₈9·9590356	₈9·9632968
2	−0·0001842	+0·0019107	₈9·9702253	₈9·9775761
3	+0·0041615	+0·0043359	₈9·9836640	₈9·9874669
4	+0·0022571	−0·0000193	₈9·9883095	₈9·9857584
5	−0·0002543	+0·0017453	₈9·9799346	₈9·9719857
6	+0·00139449	+0·0041263	₈9·9641916	₈9·9592765
S	−0·0120356	+0·0120355	9·8453606	9·8453604

	J_3		J_3	
1	−0·00585505	−0·00140226	+0·40785020	+0·80341952
2	+0·00468370	+0·00971660	+0·97976102	+0·88962359
3	+0·01115191	+0·00845479	+0·55715872	+0·07145088
4	+0·00332326	−0·00173361	−0·43735442	−0·83292266
5	−0·00513377	−0·00687857	−1·00926200	−0·91912349
6	−0·00770880	−0·00769584	−0·58665970	−0·10095402
S	+0·00046125	+0·00046111	−0·08850618	−0·08850618

	Log $\{p \times q \mathrm{N}\}$		Log $\left(\frac{r}{a}\right)\left(\frac{q}{a^3}\right)^{-\frac{1}{3}} \mathrm{M}\left(\frac{\cos\left(60-\frac{\theta}{3}\right)}{\cos\theta}\right)^{\frac{1}{3}}$	
1	9·9293839	9·9322094	0·8989321	0·8778041
2	9·9367767	9·9416173	0·8496439	0·8253422
3	9·9456301	9·9481456	0·8086417	0·7985623
4	9·9487182	9·9470473	0·7947352	0·7999840
5	9·9432020	9·9379393	0·8178429	0·8474369
6	9·9327766	9·9295283	0·8798797	0·9005482
S	9·6364875	9·6364872	5·0496755	5·0496777

	$\frac{a}{r}\mathrm{R}_0$		$\frac{a}{r}\mathrm{S}_0$	
1	−3·5542377	−3·4715104	−0·0206925	−0·0099099
2	−3·3800798	−3·3195412	+0·0104478	+0·0277033
3	−3·2909303	−3·2757000	+0·0312943	+0·0202729
4	−3·2636662	−3·2664060	+0·0031635	−0·0094760
5	−3·3061634	−3·3921547	−0·0132332	−0·0118988
6	−3·4993960	−3·5691123	−0·0129415	−0·0186450
S	−20·2944734	−20·2944246	−0·0019616	−0·0019535

	$\frac{a}{r}\mathrm{W}_0$	
1	+2·7634580	+5·1869928
2	+5·9902685	+5·2147250
3	+3·1908882	+0·4260306
4	−2·4085589	−4·6520828
5	−5·8233581	−5·5949679
6	−3·7811149	−0·6498359
S	−0·0684172	−0·0691382

The discordance in

$$\frac{a}{r} W_0$$

is large, but I cannot account for it. Lastly

$$A_0^{(c)} = -3{\cdot}3824082 \qquad B_0^{(c)} = -0{\cdot}0003263$$
$$\tfrac{1}{2} A_1^{(c)} = -0{\cdot}0719575 \qquad \tfrac{1}{2} B_1^{(c)} = -0{\cdot}0057844$$
$$\tfrac{1}{2} A_1'^{(s)} = +0{\cdot}0194409 \qquad \tfrac{1}{2} B_1^{(s)} = +0{\cdot}0098052$$
$$\tfrac{1}{2} A_2^{(c)} = -0{\cdot}0132740 \qquad \tfrac{1}{2} B_2^{(c)} = -0{\cdot}0041664$$
$$\tfrac{1}{2} B_2^{(s)} = -0{\cdot}0030421$$
$$C_0^{(c)} = -0{\cdot}0114629$$
$$\tfrac{1}{2} C_1^{(c)} = +1{\cdot}2651658$$
$$\tfrac{1}{2} C_1^{(s)} = +2{\cdot}7113348$$

S and S_1 for $\frac{1}{2} C_1^{(c)}$ are respectively

$$+7{\cdot}5928286 \text{ and } +7{\cdot}5891614,$$

and for $\frac{1}{2} C_1^{(s)}$

$$+16{\cdot}268854 \text{ and } +16{\cdot}2671640.$$

The equation

$$\sin \phi \tfrac{1}{2} A_1^{(s)} + \cos \phi B_0^{(c)} = 0$$

I find equal to

$$-0{\cdot}00000016.$$

The epoch is 1850·0

Sydney, N.S.W.:
1892 *November* 4.

Photograph of the Cluster M 34 *Persei.*

By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M 34 *Persei* R.A. $2^h\ 35^m$ Decl. north 42° 20′ was taken on 1892 December 26, with an exposure of the plate during sixty minutes. It is No. 584 in the *General Catalogue*, and is described by Sir J. Herschel as bright, very large, little compressed, scattered stars, 9th mag.

The Earl of Rosse, in his *Observations of Nebulæ and Clusters of Stars*, p. 31, describes the cluster as large, bright, scattered cluster. An isosceles triangle of stars on the north side points south to a red star which has a small companion *s. p.*

The photograph confirms the general descriptions, and presents to the eye the component stars in the cluster in their true relative positions and magnitudes for future reference. Several of the stars in and around the cluster have faint stars like

comites near them, and the photograph shows the stars down to 14th or 15th mag.

Neither Herschel nor Rosse has published drawings of the cluster, and the value of the photograph will chiefly be in the future, when other photographs have been taken and correlated with it.

Photograph of the Nebula ♅ II 240 *Pegasi.*

By Isaac Roberts, D.Sc., F.R.S.

The photograph of the nebula ♅ II 240 *Pegasi*, an enlargement of which to the scale of 15 seconds of arc to one millimetre is now presented, was taken on 1891 December 2, with an exposure of the plate during 2 hours and 36 minutes. The nebula is No. 5,046 in the *General Catalogue*, R.A. $23^h\ 58^m$, Decl. 15° 33′ north. It is figured in the *Phil. Trans.* 1861, pl. 30, fig. 42, p. 736, where the Earl of Rosse describes it as bright, pretty large, elongated, gradually much brighter in the middle; and in his *Observations of Nebulæ and Clusters of Stars* 1855 to 1860, p. 177, pl. 5, he gives another drawing of the nebula, and states that a decided dark lane runs through it, in the direction of its major axis. This feature is also shown on both the drawings which have been referred to.

Sir John Herschel, in his *Observations of Nebulæ and Clusters of Stars*, p. 481, describes the nebula as bright, large, irregularly round, 2′ or 3′ diameter, no nucleus, but he does not refer to the dark lane or to the surrounding nebulosity.

The photograph very fully confirms the observations, and the drawings made by the Earl of Rosse, excepting the widening out of the faint nebulosity at each extremity of the major axis, which the photograph does not show. The dark lane is conspicuously visible, and it divides the major axis into two equal parts. The central part of the nebula is a globular mass, and measures 41 seconds of arc in diameter, but it differs from a star in not having a central inner condensation or nucleus. The dark lane measures about eight seconds of arc in breadth, which is uniformly maintained as far as it can be traced on the photograph, except at the place where it crosses the denser part of the globular mass. There it is narrower, and less distinctly visible.

The inferences that I draw from the photograph are, that the dark lane is a ring, seen edgewise, surrounding the globular mass, and that there is another very wide, nebulous, faint ring surrounding the central mass, between it and the dark outer ring. The outer ring intercepts the light of the inner nebulous ring, and where it crosses the luminous central condensation the light is intercepted in a lesser degree, in the manner seen when the ring of *Saturn* is viewed nearly edgewise across the planet.

Telescope Objectives for Photographic Purposes.

By H. Dennis Taylor.

The larger number of telescopes for mapping and surveying the heavens by means of photography have already been made, and it may be assumed that the best form of objective to satisfy the requirements has been ascertained in practice, at any rate approximately. Nevertheless, I think that the remarks which I have to offer will certainly be of interest to those numerous members of this Society who have more or less devoted their mathematical bent of mind to the kindred science of optics, with the theoretical and practical advancement of which the science of astronomy is very closely concerned.

It was wisely decided at the Paris Convention that the standard objective for celestial photography should be so corrected as to have its minimum, or most intense focus for the G ray, to which the ordinary rapid bromide plate is most sensitive. This, together with the focal length and aperture, was about all which the Convention prescribed. It did not seem to be widely enough recognised that the *form* of the objective would have a *great deal* to do with its efficiency as regards the size of field yielded by it. Dr. Steinheil, however, conscious of the importance of the *form*, made two recommendations, which were accepted by the Convention, and which ran to this effect:—The ratio between the sine of the angle of incidence on the first surface for a ray parallel to the axis, but striking the edge of the objective, and the sine of its angle of emergence at the fourth surface, must be equal to the ratio between the sines of angles of incidence at first surface and emergence at fourth surface for another ray, also parallel to the axis, but striking the objective at a point much nearer its centre. This is the condition under which the objective will give the best possible lateral image. Also, a white ray parallel to the axis, but striking the edge of the O. G, must not only have those coloured constituents which the O. G is supposed to refract to the same focus, emerge at the fourth surface in such a manner as to proceed to the same focus, but they must also emerge *at the same point* at the fourth surface; this is the condition that the images in both colours shall be of the same size.—For my part, I confess that I do not grasp the necessary relation between Dr. Steinheil's two conditions and the two advantages respectively aimed at, although I find that the first condition certainly does hold good in an objective corrected for the largest possible field. But, granting the relations to be correct, it cannot be said that Dr. Steinheil's conditions would facilitate a direct calculation of the curves, &c., necessary to fulfil the third and fourth of the several conditions following, the first three being indispensable and the last two very desirable:—

1. The proper colour correction.
2. Freedom from spherical aberration.
3. The largest possible field of fair definition (Dr. Steinheil's first condition).
4. The images in different colours to be of the same size (Dr Steinheil's second condition).
5. Freedom from distortion; all great circles on the celestial sphere should be represented as straight lines on the sensitive plate.

I here propose to deal more especially with the fulfilment of the third condition, although I may venture a few remarks upon the others. As to the calculation of the objective for the minimum focal length for rays of any given wave length, if nicety is required in the matter, then the only method available for a direct result is to express the focal length of the whole objective in terms of the wave length by an adaptation of Cauchy's dispersion formula, somewhat after the method of Professor Harkness (in *American Journal of Science and Arts*, vol. xviii., 1879 Sept.), differentiating the focal length, thus expressed, with respect to the wave length, and equating the differential coefficient to 0; the resulting equation will then determine the relation between $\frac{1}{\rho_1}$ for the crown lens and $\frac{1}{\rho_2}$ for the flint lens, these symbols, as usual, representing the sums of the reciprocals of the radii for the crown and flint respectively. Or the relations between $\frac{1}{\rho_1}$ and $\frac{1}{\rho_2}$ may be calculated for proper colour correction with tolerably near approximation by the ordinary methods, such, for instance, as conditioning that the rays F and G shall be brought to the same focus, trusting to a subsequent slight modification of one of the surfaces for neutralising the slight over-correction which would follow.

But, assuming that the relations between $\frac{1}{\rho_1}$ and $\frac{1}{\rho_2}$ are very approximately known, we have next to consider what conditions are necessary to secure the largest possible field of view. Objectives can and do vary enormously in this respect. I could show you an objective of $4\frac{1}{2}$ inches aperture, with a convexo-concave crown, which yields an image which falls off so rapidly on leaving the optic axis, that even when using a Huygenian eyepiece of rather a high power, the bad definition towards the edge of the visual field is most striking. And, as necessarily follows, such an objective is keenly sensitive to the slightest tilt; if it is thrown "out of square" to even the slightest degree, good definition is quite destroyed.

The degree to which this imperfection is present is not a matter of curvature of the image, for it can be demonstrated that all objectives, of whatever form, yield images whose degree of curvature varies only between very narrow limits indeed, accord-

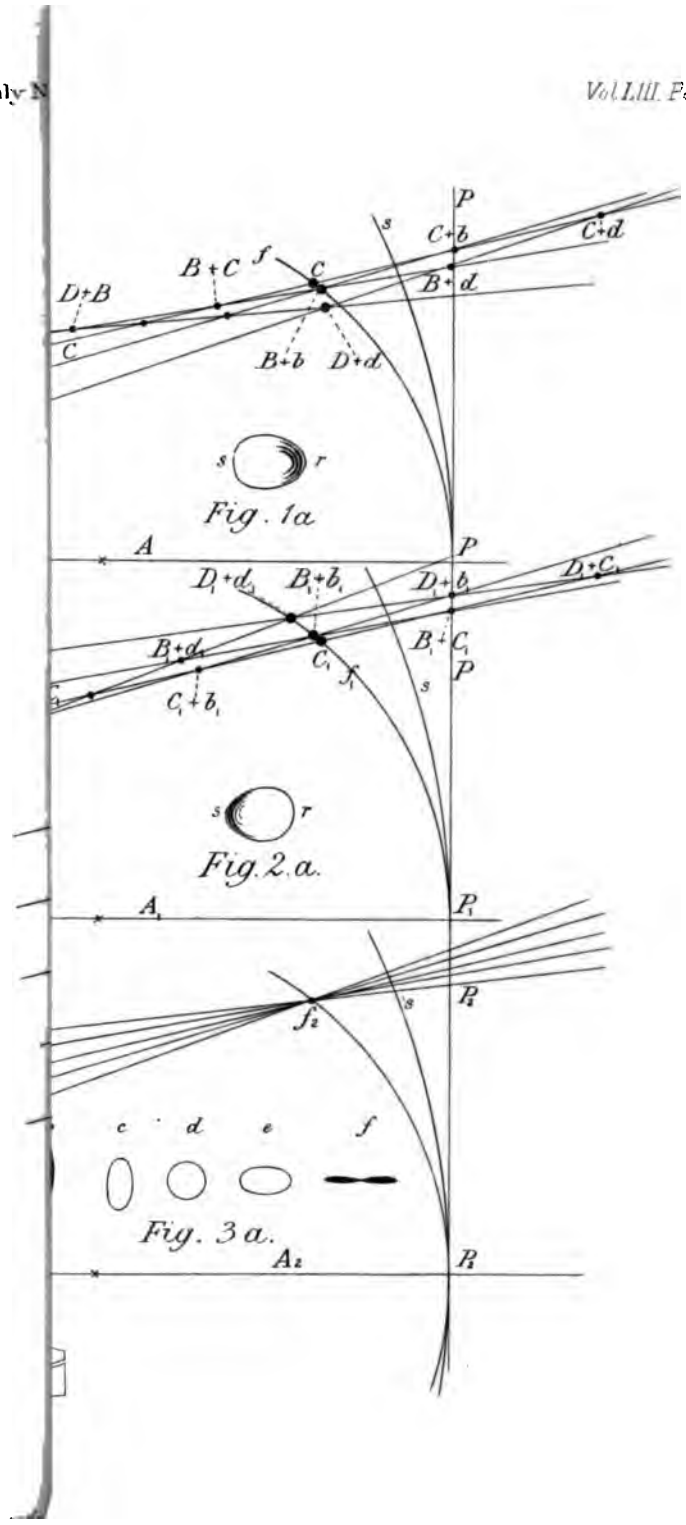


Fig. 1a

Fig. 2.a.

Fig. 3 a.

ing to the sorts of glasses employed, as I shall presently show; nor is it a matter of astigmatism either, for it can be shown that the amount of marginal astigmatism (for a standard degree of obliquity) is a constant quantity for a given focal length, and totally independent of either the curves or the sorts of glasses employed.

It may be stated broadly that the characteristic of the objective which determines whether its field of fair definition shall be small and confined to a few minutes of arc only, or extended to two degrees square or so, as required in the photographic telescope, is the degree in which it is free from the defect of "coma," or what may also be called eccentric or *unsymmetrical oblique refraction*. In Plate 7, fig. 1, L represents an achromatic and aplanatic lens, by which the oblique parallel rays (from a star) D, B, C, *b*, and *d* are refracted to a focus at *f*. Let it be supposed that the curves of L are bulged outwards somewhat towards the left, then the form of the focus at *f* will be very peculiar. Let C be that ray which passes approximately through the centre of the objective and meets with no deviation. Let B and *b* be a pair of rays at equal distances on each side of C, and D and *d* another pair of rays also symmetrical with respect to C, but still wider apart, edge rays in fact. Confining our attention to rays in primary planes (the plane of the paper being the principal primary plane), it can be shown that any pairs of rays, such as B and *b*, D and *d*, situated at equal distances from, but on opposite sides of C, come to a focus upon the primary focal curve P - - *f*, but while the ultimate focus for rays close about C is at the point C on the curve P - - *f*, the rays B and *b* focus at a point B + *b*, which is displaced laterally towards the optic axis; while the extreme pair of rays D and *d* focus at the point D + *d*, which is displaced towards the optic axis by a still larger amount. The ordinates of the curve P - - *f*, measured from the axis P - - P (the principal focal plane), are represented by

$$-F\,\frac{\tan^2\phi}{2}\left(\frac{3\mu+1}{\mu}\right)$$

where F is the principal focal length, ϕ is the angle of obliquity, and μ is (for shortness) a sort of mean between the indices of refraction for the two or more lenses of which the O.G is composed. The curve P - - *f* may be described approximately as a circle tangent to P–P, and of a radius equal to

$$F\,\frac{\mu}{3\mu+1}.$$

Thus the radius of this curve, P - - *f* will be found to be generally about $\frac{3}{4}$F of the focal length, while in secondary planes the focal curve is of a radius equal to

$$F\,\frac{\mu}{\mu+1}.$$

or generally about $\frac{3}{5}$ of the focal length. The mean between these values or

$$F\frac{\mu}{2\mu+1},$$

therefore represents the radius of curvature of the curve or locus *of circles of least confusion*, or the curve along which the most distinct image is formed. Thus the most distinct image is formed on a curve having a radius of curvature of $\frac{3}{5}$ of the focal length, generally speaking.

Returning again to the lateral displacement along the primary focal curve P - - *f*, to which the foci of the symmetrical pairs of rays B and *b*, D and *d*, are subject, it will be seen readily from fig. 1 that the consequence of this peculiar arrangement is that the foci for any *eccentric* pairs of rays, such as D and B, *b* and *d*, B and C, C and *d*, &c., are thrown altogether off the focal curve P - - *f*. The pair D and B focus at the point D + B, far short of the curve P - - *f*, while such an eccentric pair of rays as *b* and *d*, lying on the other side of C, have their focus or point of intersection quite beyond the curve P - - *f*, at a point (beyond the edge of the diagram) which may be actually beyond the principal focal plane P - - P. I have marked most of the intersection points for any two rays by corresponding couples of letters. Of course the diagram is exaggerated for the sake of clearness.

The effect of placing a circular aperture or diaphragm *behind* the lens L becomes evident on inspection. If it is placed as shown in fig. 1, then only the *eccentric* pair of rays C and *b* are allowed to pass, and these intersect or have their focus at the point C + *b*, just about on the principal focal plane P - - P; thus the diaphragm or stop *may* render the field of view perfectly flat for rays in primary planes. But if the stop were placed in front of L, it is evident that the effect would be to render the image more curved than before.

Now, if a piece of ground glass is placed across the focus at *f*, it will be found, if the source of light is bright enough, that there is no distinct image such as a point, line, or circle of light, but a curious balloon-shaped penumbra (sometimes called a "coma," if not too violent), which I have endeavoured to represent in fig. 1 *a*. *r* is the smaller and brighter end, and is where the most intense concentration of rays occurs, it being the place about which the ultimate centre ray and those close about it focus at C. The larger end, *s*, is much less bright and more diffused, and corresponds to where the more extreme rays, such as D and *d*, come to focus.

Thus in the case represented in fig. 1 the greater bulk of the coma or penumbra falls *towards* the optic axis of the lens, and the brighter end away from it. Now in fig. 2 is shown another form of lens whose curves are bulged towards the right hand. Here the manner in which symmetrical and eccentric

pairs of oblique rays respectively are refracted by the lens is exactly opposite in character to that exhibited in fig. 1; C_1 being the ultimate focus for the central ray C_1 - - C_1, and the focal points B_1+b_1, D_1+d_1, for symmetrical pairs of rays B_1 and b_1 and D_1 and d_1 being displaced along the primary focal curve P - - f_1 in the opposite direction to that prevailing in fig. 1. In the case of fig. 2, therefore, the "coma" or penumbra, fig. 2 *a*, is opposite in character to fig. 1 *a*, its more diffused bulk being thrown *away from* the optic axis A_1 - - A_1, and inspection of fig. 2 makes it clear that in order to flatten the field of view a diaphragm or stop should be placed in front of the lens, and not behind it. The behaviour of these two lenses is thus opposite in character; they both give what I may conveniently call unsymmetrical oblique refraction, but of opposite tendencies; therefore it will easily be seen that a lens intermediate in form between that shown in fig. 1 and that shown in fig. 2 should be possible, which would be free from this unsymmetrical oblique refraction. This is actually the fact. Fig. 3 illustrates the action of such a lens.

In figs. 1 and 2 we get a focus for oblique rays in which are present the inevitable faults of astigmatism and curvature of field, with the additional fault of "coma" superimposed; while in fig 3 we get astigmatism and curvature of field only, without the further blemish of "coma," and consequently if we are using a lens at open aperture, as is done in the case of telescope objectives for photographic purposes, then the best possible image off the axis is secured when such objective is designed to be free from "coma." On inspecting fig. 3, since it is seen that all pairs of rays whatsover, whether symmetrical or eccentric, intersect or come to focus (in primary planes) at one and the same point f_2, *it follows that no diaphragm or stop, whether placed in front of or behind the lens, can exert any effect whatever in the way of either flattening or rounding the field of view.* Therefore if an objective is required which will give the best possible definition off the optic axis when used at open aperture, then its curves must be so calculated that its field of view cannot be either flattened or rendered more curved by the presence of any stop, either in front of or behind the objective; or, in other words, its diaphragm corrections must be eliminated or reduced to zero.

A formula is therefore required which will render this calculation possible. Rather more than a year ago I undertook a mathematical investigation of the form of an oblique pencil of rays after refraction through one or more lenses, both when such lenses were used at open aperture, and also when armed with stops or diaphragms, either in front or behind them, partly on the lines laid down by Coddington in his *System of Optics*, but in my own investigations dealing with large apertures and taking fully into account the effects of spherical aberration upon oblique rays at each surface. I undertook this on independent lines, partly

because I could not follow Coddington throughout his processes, for he does not always clearly explain himself, as students of his work often realise. I cannot give within reasonable space the processes* by which I arrived at the general formula which I here venture to present, and which I have found to be in exact agreement with practice, provided that the thicknesses of the lenses are not disproportionately large. The formula represents a correction to the *reciprocal* of the focal length, and I will write it in a form suited to an objective of two lenses:

μ = refractive index of 1st lens
M = " of 2nd lens
f_1 = principal focal length of 1st lens
f_2 = " of 2nd lens

α_1 (as in *Coddington's Optics*) is the characteristic of the relative state of divergence or convergence of the axial rays entering the 1st lens; thus if + or $-u$ is the distance (measured axially) from which rays are diverging, or to which they are converging respectively into 1st lens, then

$$\frac{1+\alpha_1}{2f_1}=\frac{1}{u}$$

as the case may be; while

$$\frac{1-\alpha_1}{2f_1}=\frac{1}{v}$$

or the reciprocal of the corresponding conjugate focus, with its sign assessed consistently with that of $\frac{1}{u}$.

α_2 expresses the same for the 2nd lens as α_1 does for the 1st lens.

x_1 is the characteristic of the *shape* of the 1st lens, in the same sense as in Coddington's notation.

Thus, let

$$\frac{1}{\rho_1}=\frac{1}{r_1}+\frac{1}{s_1}$$

or the sum of the reciprocals of the two radii, which are of the same (+) sign if turned in opposite ways (as in a double convex or double concave lens), and of opposite signs when turned the same way (as in a positive or negative meniscus lens); then

$$\frac{1+x_1}{2\rho_1}=\frac{1}{r_1} \text{ and } \frac{1-x_1}{2\rho_1}=\frac{1}{s_1}.$$

* The formulæ previously given are deduced from these processes.

or, as Coddington expresses it,

$$\frac{1+x_1}{2(\mu-1)f_1}=\frac{1}{r_1} \text{ and } \frac{1-x_1}{2(\mu-1)f_1}=\frac{1}{s_1}.$$

Thus, according to Coddington's beautiful device, if a lens is equi-convex, then its characteristic $x=0$; if it is convexo-plane, then $x=+1$; if plano-convex, then $x=-1$; and, it always being premised in this system that light passes through lenses from left to right, a meniscus with its convex side towards the left has its characteristic $x=$ something greater than 1; if turned round the other way, x is minus quantity greater than 1, its numerical value being the same. Thus, turning a lens back to front merely changes the *sign* of its characteristic x.

x_2=the characteristic of the shape of the 2nd lens.

U=the axial distance from the 1st lens of the point from which the light is diverging.

D = the distance of the stop or diaphragm from the centre of the first lens. When D is in front of a lens (whether a positive or negative lens) then it is of + sign, but when behind a lens it is of — sign.

In the following formula it should be carefully borne in mind that the two terms U and D, wherever they occur, have their value determined in reference to the *first* lens only; for, in the formulæ extended for three, four, or more thin lenses in contact, the values of U and D, if the stop is in front (or V and —D if the stop is behind), must be determined solely in relation to that lens which lies next to the stop, the necessity for allowing for *virtual* images of the stop being obviated in this method.

ϕ = the angle of obliquity, or the angle included between the optic axis and that ray of the entering pencil which passes through the centre of the lens.

Premising, moreover, that the corrected focal distance for an oblique pencil is measured parallel to the optic axis, or, in other words, referred to the axis by dropping a perpendicular to the latter, and that the *axial* focal length is the standard to whose reciprocal the correction expressed by the following formula is to be applied in order to arrive at the focal length for the oblique pencil, then we have the following formula relating to the case of a double objective with crown lens placed first and with a stop or diaphragm placed axially at a distance D in front of the crown lens.

Then the correction to the reciprocal of the axial focal length is, for rays in *primary* * planes:

* The formula for rays in secondary planes is exactly the same, except that $3\tan^2\phi$ is replaced by $\tan^2\phi$.

$$\frac{3\tan^2\phi}{8f_1^3\mu(\mu-1)}\left[\left\{\frac{\mu+2}{\mu-1}x_1^2+4(\mu+1)a_1x_1+(3\mu+2)(\mu-1)a_1^2+\frac{\mu^2}{\mu-1}\right\}\right.$$
$$\left.+2f_1\left\{4\mu^2a_1+2(\mu+1)(x_1-a_1)\right\}\frac{U-D}{UD}\right]\frac{D^2U^2}{(U-D)^2}$$
$$-\frac{3\tan^2\phi}{8f_2^3M(M-1)}\left[\left\{\frac{M+2}{M-1}x_2^2+4(M+1)a_2x_2+(3M+2)(M-1)a_2^2+\frac{M^2}{M-1}\right\}\right.$$
$$\left.-2f_2\left\{4M^2a_2+2(M+1)(x_2-a_2)\right\}\frac{U-D}{UD}\right]\frac{U^2D^2}{(U-D)^2}.$$

The first two lines express the diaphragm corrections for the first or crown lens in the way of alteration in the curvature of its image, dependent upon the presence of the stop in front; while the last two lines express the corrections for the second or negative lens due to the presence of the same stop in front. Now we have already concluded that the form of objective which will give the largest possible field when used at open aperture, or yield the best possible lateral image, is a form which cannot in any way have its field of view modified by the presence of a stop placed at any distance either in front of or behind it, an objective, in fact, *whose curves are such that the formulæ expressing its diaphragm corrections equate to* o.

On inspecting the above formulæ, students of optics familiar with Coddington's work* will at once recognise in the first and third lines the formulæ which express the spherical aberration of the objective, only that y^2 is replaced by the common factor

$$\left(\frac{DU}{U-D}\right)^2 3\tan^2\phi.$$

These two lines multiplied by the above factor then express those diaphragm corrections or modifications of the curvature of field which are dependent upon the presence of spherical aberration in the objective. But since a properly constructed

* Those who have at all followed Coddington in his investigation of the form of a pencil of rays after refraction through a lens eccentrically and obliquely, will be aware that the results he arrives at are decidedly confusing, diaphragm corrections due to the spherical aberration of the lens and diaphragm corrections depending upon the *form* of the lens (on which latter the amount of "coma" is dependent) being altogether mixed up. His results are only useful when applied to pencils of very small aperture, and there is little doubt that it was the confusion I have just alluded to, which prevented him realising the advantages which one form of lens may have over another when used at open aperture, and prompted him to write (See his *System of Optics*, page 159): "The next question that offers itself is the advantage to be derived from a combination of lenses when a pencil passes through it centrically but obliquely. It will, however, easily be seen that as *the effects of obliquity in this case are totally independent of the form of a single lens*, so they cannot be removed or diminished by any combination." The italics are my own.

objective is necessarily free from spherical aberration, these first and third lines of the formulæ may be neglected as being equal to zero, and we get, after crossing out common factors,

$$\frac{1}{f_1^2\mu(\mu-1)}\left\{2\mu^2\alpha_1+(\mu+1)(x_1-\alpha_1)\right\}$$

for crown lens

$$+\frac{1}{f_2^2\mathrm{M}(\mathrm{M}-1)}\left\{2\mathrm{M}^2\alpha_2+(\mathrm{M}+1)(x_2-\alpha_2)\right\}$$

for negative lens.

Expressing f_2 by δf_1, this formula will be found to equate to o when

$$x_2=-x_1\frac{\delta^2\mathrm{M}(\mathrm{M}-1)(\mu+1)}{\mu(\mu-1)(\mathrm{M}+1)}-\frac{(\mathrm{M}-1)\{\delta^2\mathrm{M}(2\mu+1)\alpha_1+\mu(2\mathrm{M}+1)\alpha_2\}}{\mu(\mathrm{M}+1)}.$$

This is the condition under which the objective is free from "coma," and therefore yields the best possible lateral image. As a concrete instance, let an objective of ordinary crown and flint be considered where, since the incident rays are parallel,

$$_1=-1;\ \mu_G=1;\ \cdot5276 \text{ and } \mathrm{M}_G=1\cdot6415,$$

and δ, or the dispersive ratio for the spectrum interval F to G = 1·762, which is therefore the focal ratio, on the condition that the rays F and G are brought to the same focus. Inserting these values in the above formula, we get

$$x_2=-3\cdot88234\,x_1+\cdot66056.*$$

This value for x_2 may then be inserted in the formulæ for spherical aberration, which will be found to equate to o when

$$x_1=-\cdot255.$$

* There is another method of arriving at the curves for an objective free from "coma," provided that the most exact result is not required. It can be proved that if an objective is so designed that it shall be as nearly as possible aplanatic for converging and diverging rays as well as for parallel rays, then it will be very approximately free from coma when focussed on infinitely distant objects. Thus, if the formula expressing the spherical aberration of the objective is differentiated with respect to α_1 and α_2 (changes in the values of which, of course, express changes in the state of convergence or divergence of the entering rays), and the relative values of x_1 and x_2 which are necessary to equate the differential coefficient to o when $\alpha_1 = -1$ are then inserted in the complete formula for spherical aberration, then the latter, on being equated to o, will yield the proper value for x_1 and x_2. This method should and does yield a form of objective whose curves are rather more bulged towards the focus than the form obtained by the more exact method of eliminating diaphragm corrections.

Therefore the radius of the first surface of the crown lens will be to the radius of the second surface as 5 : 3, broadly speaking. This calculation is exactly verified by practical results. In Fig. 4 I have represented an objective of this form. The inner curve of the flint is only very slightly flatter than that of the crown, and if a crown of lower dispersive power, such as Schott's boro-silicate crown (a very hard and beautifully colourless glass) were united with a dense flint, such as is used for ordinary prisms, then all the optical conditions may be satisfied consistently with the two inner curves being worked exactly to the same radius, so as to permit of cementing, if the objective is not too large for this to be practicable.

On tilting such an objective as this ever so much out of square, no trace of coma will be shown, the appearances being astigmatism pure and simple, as shown in Fig. 3 *a*, and varying in amount according to the square of the tangent of the angle of obliquity. It scarcely needs pointing out that an objective approaching this form is also highly desirable for transit instruments, whose eyepieces are often provided with a large amount of lateral travel.

Buckingham Works, York:
1893 *April* 8.

Results of Double-Star Measures with the 8-inch Equatoreal at Windsor, N. S. Wales, in 1892. By John Tebbutt.

Ref. No.	Star.	Observed Magnitude.	Approx. Place of Star. R. A.	Dec. S.	Fraction of Year.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour-Angles.		Weight, 1 to 5.
			h m	° ′		°		″			h m	h m	
1	*p* Eridani	...	1 36	56 45	·750	225·7	10	...	...	300	2 50 E	2 27 E	...
2	,,	...	,,	,,	·925	...	...	7·01	6	170	1 28 E	1 17 E	4
3	,,	...	,,	,,	·925	226·4	10	...	...	230	1 3 E	0 44 E	4
4	,,	...	,,	,,	·928	226·9	10	...	...	300	1 30 E	1 11 E	4
5	*h* 4373	9, 9	10 44	41 0	·457	...	...	6·01	5	100	2 31 W	2 41 W	2
6	α Crucis	...	12 21	62 30	·482	120·0	10	4·92	6	...	2 17 E	1 47 E	3 & 2
7	,,	...	,,	,,	·542	116·6	10	4·82	7	300	1 33 W	2 3 W	4
8	γ Centauri	...	12 36	48 22	·441	0·0	10	...	...	300	2 22 E	2 4 E	4
9	,,	6, 6	,,	,,	·444	359·0	10	...	...	300	2 13 E	1 50 E	4
10	,,	...	,,	,,	·446	...	...	1·46	10	170	2 47 E	2 26 E	4
11	,,	...	,,	,,	·449	...	...	1·42	10	170	2 37 E	2 21 E	4
12	,,	4, 4	,,	,,	·457	...	...	1·94	10	170	1 1 W	1 24 W	3
13	,,	4, 4	,,	,,	·460	359·8	10	1·71	10	300	2 2 E	1 27 E	4
14	,,	...	,,	,,	·482	357·3	10	1·69	10	300	1 47 E	1 10 E	5
15	,,	...	,,	,,	·487	359·0	10	1·72	8	300	1 28 E	1 6 E	4
16	,,	...	,,	,,	·597	358·0	10	1·82	7	535	2 0 W	2 29 W	4
17	,,	...	,,	,,	·600	357·9	10	1·50	7	535	1 50 W	2 15 W	5
18	γ Virginis	...	12 56	0 51	·485	151·7	10	5·51	8	300	1 31 E	1 4 E	4

Ref. No.	Star.	Observed Magnitude.	Approx. Place of Star. R. A.	Approx. Place of Star. Dec. S.	Fraction of Year.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour-Angles.		Weight, 1 to 5.
			h m	° ′		°		″			h m	h m	
19	γ Virginis	...	12 56	0 51	·545	152·9	10	5·61	8	300	0 19 W	0 46 W	4 & 3
20	β Muscæ	3½, 3½	12 40	67 31	·457	...	...	1·32	8	170	1 34 W	1 58 W	1
21	,,	...	,,	,,	·457	333·2	10	...	...	300	2 14 W	2 26 W	1
22	,,	...	,,	,,	·460	337·7	10	...	...	300	1 18 E	0 58 E	2
23	,,	...	,,	,,	·460	335·9	5	...	...	300	0 3 W	0 9 W	3
24	,,	...	,,	,,	·471	334·2	10	1·34	8	300	1 37 E	1 6 E	4
25	,,	...	,,	,,	·476	338·7	10	...	...	535	1 28 E	1 10 E	1
26	,,	...	,,	,,	·482	335·0	10	...	...	300	3 20 E	2 54 E	3
27	,,	...	,,	,,	·487	334·7	8	...	...	300	1 4 E	0 48 E	2
28	,,	...	,,	,,	·542	336·5	10	...	...	300	0 25 W	0 39 W	2
29	h 4634	8, 9	13 51	55 28	·441	19·9	10	...	...	140	1 19 E	1 0 E	...
30	,,	8, 9	,,	,,	·444	20·1	10	...	...	140	2 6 E	1 36 E	3
31	,,	8, 9	,,	,,	·446	...	...	12 64	7	110	1 28 E	0 24 E	3
32	,,	8, 9	,,	,,	·449	...	...	12·84	10	100	1 58 E	1 33 E	3
33	,,	8, 9	,,	,,	·471	19·4	10	12·11	7	140	1 7 E	0 33 E	3
34	α Centauri	...	14 32	60 23	·441	205·3	10	...	...	230	1 21 E	1 1 E	3
35	,,	1, 2	,,	,,	·444	206·1	10	...	...	300	2 0 E	1 46 E	2
36	,,	...	,,	,,	·446	...	...	19·80	10	170	4 12 E	3 54 E	3
37	,,	1, 2	,,	,,	·449	...	...	20·24	10	170	4 6 E	3 44 E	3
38	,,	...	,,	,,	·460	205·1	10	...	...	140	4 37 E	4 24 E	4

Ref. No.	r.	Observed Magnitude.	Approx. Place of Star. R. A.	Dec. S.	Fraction of Year.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour-Angles.		Weight, 1 to 5.
			h m	° ′		°		″			h m	h m	
39	α Centauri	1, 2	14 32	60 23	·460	205·4	10	...	...	140	4 24 E	4 11 E	4
40	„	...	„	„	·463	205·3	10	19·67	10	300	3 52 E	3 20 E	3
41	„	...	„	„	·463	205·9	10	...	...	300	1 36 E	1 14 E	3
42	„	...	„	„	·471	205·4	10	19·30	7	300	0 39 E	0 11 E	3
43	„	...	„	„	·482	205·7	10	19·37	7	...	3 2 E	2 37 E	4
44	„	...	„	„	·485	205·5	10	19·58	6	300	0 47 E	0 21 E	4
45	„	...	„	„	·526	205·7	10	19·85	10	300	1 40 W	2 12 W	3
46	„	...	„	„	·597	206·0	10	...	...	535	1 41 W	2 0 W	4
47	„	...	„	„	·600	205·4	10	...	...	535	1 9 W	1 30 W	3
48	„	...	„	„	·613	206·0	10	...	...	535	0 30 W	0 49 W	2
49	„	...	„	„	·613	205·6	10	19·97	7	535	3 20 W	3 53 W	4
50	„	...	„	„	·753	206·7	10	19·89	10	300	1 38 W	2 13 W	3
51	π Lupi	5, 5	14 58	46 38	·441	86·5	10	...	...	300	1 10 E	0 48 E	2
52	„	5, 5	„	„	·444	86·9	10	...	...	300	1 59 E	1 43 E	4
53	„	5, 5	„	„	·446	..	...	1·34	6	170	1 16 E	1 6 E	3
54	„	5, 5	„	„	·449	...	...	1·41	8	170	2 15 E	1 56 E	3
55	„	...	„	„	·460	87·0	10	...	...	300	0 48 E	0 30 E	3
56	„	...	„	„	·753	88·1	10	1·48	5	300	3 52 W	4 15 W	3
57	„	...	„	„	·756	88·7	10	1·47	5	300	4 6 W	4 30 W	4
58	Lacaille, 6477	7, 7	15 38	65 6	·471	155·8	10	1·96	8	300	1 5 E	0 38 E	5
59	„	7, 7	„	„	·485	154·3	10	2·07	5	300	0 43 E	0 12 E	3

Ref. No.	Star.	Observed Magnitude.	Approx. Place of Star. R. A.	Dec. S.	Fraction of Year.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour-Angles.		Weight, 1 to 5.
			h m	° ′		°		″			h m	h m	
60	ρ Ophiuchi	...	16 19	23 12	·438	354·8	10	3·23	8	300	...	0 4 W	...
61	„	...	„	„	·463	354·7	10	3·39	8	300	2 7 E	1 36 E	4
62	36 Ophiuchi	...	17 9	26 26	·463	195·3	10	4·32	7	300	2 8 E	1 42 E	4 & 3
63	„	4, 4	„	„	·471	195·7	10	4·11	7	300	1 56 E	1 30 E	5
64	Brisbane, 6556	7, 7½	18 54	37 13	·460	281·3	10	12·57	7	230	3 16 E	2 41 E	4
65	γ Cor. Aust.	...	18 59	37 13	·460	173·4	10	...	...	300	2 42 E	2 23 E	3
66	„	4. 4	„	„	·471	173·9	10	1·69	10	300	2 58 E	2 33 E	5
67	„	...	„	„	·753	170·5	10	1·61	10	300	1 53 W	2 44 W	5
68	„	...	„	„	·756	174·7	10	...	...	300	1 10 W	1 42 W	4
69	„	...	„	„	·756	172·2	10	...	...	300	2 57 W	3 22 W	5

Remarks.

The columns headed "Hour Angles" denote the hour angles between which the measures were made, and the last column the weight assigned to the observations from a consideration of the conditions under which they were made. 1 denotes the worst and 5 the best conditions possible.

Nos. 2, 3, 4, 5, 7, 8, 13, 14, 15, 16, 17, 18, 20, 21, 26, 29, 33, 34, 38, 39, 40, 41, 42, 43, 44, 45, 49, 61, 62, 63, 65, 66, 67, 69. The line joining the observer's eyes was parallel to that joining the components.

Nos. 6, 12, 19, 22, 23, 24, 27, 28, 46, 47, 48, 50, 51, 56, 57, 58, 59, 64, 68. These lines were at right angles.

Nos. 8, 9, 10. 11, 12, 13, 15, 18, 20, 51. 52, 53. 54, 58, 59, 63, 65. Components equal.

No. 5. The determination of the place of this star is uncertain.

No. 25. Observations of little value.

No. 26. The south component certainly the brighter.

No. 32. The clock acted badly.

Nos. 38, 39, 45, 50. Measures in sunlight.

Nos. 2, 4, 13, 28, 48, 56, 57. Measures in twilight.

Nos. 14, 40. Measures partly in sunlight and partly in twilight.

Windsor, N. S. Wales:
1893 *February* 11.

On the Orbit of O Σ 285. By J. E. Gore.

Recent measures made by Mr. Burnham with the 36-inch refractor of the Lick Observatory, show that the angular change in this pair, since its discovery, amounted last year to 270°. I have computed the orbit and find the following provisional elements:—

Elements of OΣ 285.

P = 118·57 years	Ω = 106° 58′
T = 1881·93	λ = 161° 24′
e = 0·58	a = 0″·46
i = 45° 42′	μ = −3°·036

The following is a comparison between the measures used in computing the orbit and the positions computed from the above elements. A correction of 180° has been applied to the measures marked with an asterisk, the components being nearly equal in brightness:—

Epoch.	Observer.	θ	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
1845·80	O. Struve	72°·2	73°·5	−1°·3	0″·61	0″·56	+0″·05
1847·96	Mädler	72·2	70·9	+1·3	0·42	0·53	−0·11
1852·69	,,	60·6	64·2	−3·6	0·45	0·48	−0·03
1852·74	O. Struve	57·8	64·1	−6·3	0·50	0·48	+0·02
1855·84	,,	53·9	58·8	−4·9	0·51	0·44	+0·07
1857·50	Secchi	65·5	55·6	+9·9	0·4	0·41	−0·01
1865·50	Dembowski	36·5	32·3	+4·2	oblong?	0·30	...
1881·50	Burnham		Round or doubtful			0·19	...
1883·84	Engelmann	*258·3	252·4	+5·9	0·22	0·17	+0·05
1885·40	Perrotin	*225·0	232·3	−7·3	oblong?	0·16	...
1887·56	Schiaparelli	202·2	204·3	−2·1	0·24	0·17	+0·07
1891·30	Burnham	168·7	169·0	−0·3	0·24	0·23	+0·01
1892·30	,,	162·2	162·2	0·0	0·21	0·25	−0·04

Assuming that the mass of the system is equal to the mass of the Sun, the "hypothetical parallax" would be

$$p = \frac{a}{P^{\frac{2}{3}}} = 0''{\cdot}019.$$

The magnitudes of the components are about 7·0, 7·2; and the approximate position of the pair for 1880·0 is

R.A. $14^h\ 41^m$
Decl. +42° 53′.

Observations of the recent Conjunction of Saturn and γ Virginis made at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The following observations of differences of R.A and N.P.D. were made with the $12\frac{3}{4}$-inch Merz Refractor mounted on the Lassell Equatorial, the power used being 285. The differences of R.A. were recorded on one of the portable chronographs, and the differences of N.P.D. were measured with a filar micrometer:—

TABLE I.

G.M.T. of Observation.	γ' Virg.-Sat. Corrected for Refraction and Parallax.	γ' Virg.-Sat. Corrected for Refraction and Parallax.	Diameter of Saturn.	Deduced R.A. of Sat. Reduced to Time of Meridian Passage.	Observer.
d h m s	m s	m s	s	h m s	
Apr. 10 9 46 46	0 38·78	...	1·26	12 35 35·82	L.
49 29	38·84	...	·24	·80	L.
54 54	38·88	...	·21	·82	L.
56 1	...	0 39·03	·25	·87	L.
57 17	...	39·16	·23	·76	L.
58 38	...	39·08	·27	·86	L.
10 0 36	39·06	...	·23	·70	L.
1 55	38·95	...	·24	·83	L.
3 12	39·00	...	·25	·79	L.
6 45	39·01	...	·38	·82	H. T.
8 22	...	39·29	·29	·75	H. T.
9 43	...	39·21	·25	·84	H. .
10 56	39·08	...	·26	·80	H. T.
12 29	...	39·28	·33	·80	H. T.
15 14	39·10	...	·31	·82	H. T.
32 32	39·16	...	·33	·96	L.
34 17	...	39·57	·25	·77	L.
35 27	39·27	...	·23	·89	L.
36 32	...	39·53	·23	·83	L.
37 43	39·37	...	·33	·81	L.
48 23	39·44	...	·21	·87	L.
49 30	...	39·72	·29	·79	L.
50 46	39·49	...	·26	·84	L.
51 53	...	39 62	·26	·92	L.

G.M.T. of Observation.	γ' Virg.-Sat. Corrected for Refraction and Parallax.	γ' Virg.-Sat. Corrected for Refraction and Parallax.	Diameter of Saturn.	Deduced R.A. of Sat. Reduced to Time of Meridian Passage.	Observer.
d h m s	m s	m s	s	h m s	
Apr. 10 10 53 35	39·52	...	·23	12 35 35·85	L.
54 39	...	39·70	·29	·87	L.
12 9 12 3	1 11·33	...	·21	2·97	L.
13 54	...	1 11·63	·22	·88	L.
15 40	11·41	...	·28	·93	L.
17 26	...	11·60	·23	·95	L.
19 17	11·39	...	·28	·99	L.
21 9	...	11·69	·29	·90	L.
49 2	11·75	...	·24	·97	L.
50 43	...	11·97	·26	·96	L.
52 31	11·68	...	·29	3·08	L.
54 13	...	12·05	·23	2·92	L.
10 17 57	12·16	...	·21	·90	L.
19 46	...	12·32	·26	·95	L.
21 34	12·23	...	·28	·87	L.
23 9	...	12·37	·24	·94	L.
41 58	12·39	...	·23	·94	L.
43 43	...	12·64	·26	·90	L.
45 25	...	12·61	·27	·95	L.
47 11	12·47	...	·28	·92	L.
49 14	12·48	...	·26	·93	L.
50 58	...	12·68	1·29	2·95	L.

The initials H. T. and L. are those of Mr. Turner and Mr. Lewis respectively.

	R.A.	N.P.D.
	h m s	° ′ ″
Assumed apparent place of γ^1	12 36 15·65	90 51 53·6
„ „ γ^2	15·84	58·7

The apparent place is sensibly the same on both days.

The authority for these is the Greenwich Five-Year Catalogue of Fundamental Stars 1890·0.

	R.A.	N.P.D.
	d h m s	° ′ ″
N.A. Tabular place of *Saturn* at Meridian passage	10 12 35 36·04	90 53 54·0
„ „ „ „	12 12 35 3·15	90 50 28·9

TABLE I. (Part 2).

Differences of N.P.D. of Saturn and γ^1 and γ^2 Virginis.

G.M.T. of Observation.				γ^1 Virg.-Sat. Corrected for Refraction and Parallax.	γ^2 Virg.-Sat. Corrected for Refraction and Parallax.	Diameter of Saturn.	Difference of γ^1-γ^2 Virg.	Seconds of Deduced N.P.D. of Saturn reduced to time of Meridian Passage.		Observer.
								from γ^1	from γ^2	
d	h	m	s	′ ″	′ ″	″	″	″	″	
Apr. 10	10	21	33	−2 2·24	−1 56·97	18·25	5·27	51·8	51·6	L.
		23	35	2·93	57·90	18·14	5·03	52·6	52·6	L.
		24	30	2·18	57·26	18·25	4·92	51·9	52·1	L.
		25	30	2·46	57·04	18·30	5·42	52·2	51·9	L.
		27	7	2·28	57·04	18·58	5·24	52·2	52·0	L.
		40	28	1·78	57·27	17·88	4·51	52·7	53·2	L.
		41	48	0·76	55·95	18·54	4·81	51·7	52·0	L.
		42	56	2·14	56·90	18·64	5·22	53·2	53·1	L.
		44	9	1·13	56·13	18·54	5·00	52·3	52·3	L.
		46	3	1·63	56·91	18·23	4·72	52·9	53·3	L.
12	9	35	23	+1 19·89	+1 24·56	18·33	4·67	27·0	27·5	L.
		37	15	20·06	25·14	19·66	5·08	27·0	27·0	L.
		39	26	20·04	24·40	18·98	4·36	27·2	27·9	L.
		42	23	20·01	25·08	18·91	5·07	27·4	27·4	L.
		44	25	19·92	24·58	18·82	4·66	27·6	28·1	L.
		59	37	21·26	26·32	18·44	5·06	27·4	27·4	L.
	10	1	41	21·95	27·21	17·60	5·26	26·8	26·7	L
		10	2	22·46	27·39	18·25	4·93	26·9	27·1	L.
		12	0	22·62	27·63	18·52	5·01	26·9	27·0	L.
		13	56	22·46	27·02	17·56	4·56	27·2	27·7	L.
		32	1	22·91	27·93	17·32	5·02	28·0	28·1	L.
		33	42	23·98	28·89	17·60	4·91	27·1	27·3	L.
		35	32	23·86	28·70	18·10	4·84	27·3	27·6	L.
		37	12	24·80	29·52	17·55	4·72	26·5	26·9	L.
		39	0	24·54	30·06	18·33	5·52	26·9	26·4	L.

Collecting the results, we obtain—

Correction to Tabular R.A. of Saturn, as given in the "Nautical Almanac."

Date.	Observer.	From γ^1.		From γ^2.	
		s	s	s	s
Apr. 10	L.	−0·208	±·008	−0·206	±·010
	H. T.	−0·227	±·020	−0·243	±·020
12	L.	−0·200	±·009	−0·220	±·009

Correction to Tabular N.P.D. of Saturn.

Apr. 10	L.	−1″·65	±0″·11	−1″·59	±0″·11
12	L.	−1·75	±0·10	−1·56	±0·10

Preparations were also made for observations on April 8 and 9, but no measures could be obtained, as during the earlier part of the night *Saturn* was behind the new building (on which the Lassell Equatorial is shortly to be mounted), and the sky clouded over afterwards on each night.

Saturn and γ *Virginis* were also observed with the transit circle on April 10 and 12, and the following are the resulting differences of R.A. and N.P.D.:—

TABLE II.

G.M.T.	Observer.	γ^1−Sat. R.A.	γ^2−Sat. R.A.	γ^1−Sat. N.P.D.	γ^2−Sat. N.P.D.	Diameter. R.A.	Diameter. N.P.D.
d h m		m s	m s	′ ″	′ ″	s	″
Apr. 10 11 18·0	R. C.	0 39·75	...	−2 0·55	...	1·16	19·71
12 11 9 6	H.	1 12·66	1 12·97	1 25·83	1 31·47	1·30	18·66

The N.P.D. differences are corrected for refraction and parallax.

The initials R. C. and H. are those of Mr. Cheeseman and Mr. Hollis.

Photographs of *Saturn* and γ *Virginis* were taken with the Astrographic Equatorial on April 7, 10, 12, and 13 with a series of exposures and trails for orientation.

Royal Observatory, Greenwich:
1893 *April* 14.

Revised Places of Comets observed at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

Since the comet observations in the *Monthly Notices*, vol. liii. Nos. 1 to 5, were communicated to the Society, more accurate places have been found for many of the comparison stars, chiefly in the Lund and Leiden zones. These places are given below, together with the resulting positions of the comets.

Holmes' Comet (*f* 1892).

Greenwich Mean Solar Time.	R.A. of ✓.	N.P.D. of ✓.	Comp. ✱	References to *Monthly Notices* of R.A.S.
1892. d h m s	h m s	° ′ ″		
Nov. 9 9 36 26	0 45 51·90	51 41 19·4	*k*	Vol. liii., No. 1, p. 52
9 11 22 53	0 45 52·51	51 41 33·1	*g*	,, ,, ,,
10 6 17 48	0 45 23·61	51 46 12·6	*k*	,, ,, ,,
10 6 17 48	0 45 26·10	51 45 51·7	*e*	,, ,, ,,
10 6 25 3	0 45 27·30	51 45 48·6	*e*	,, ,, ,,
12 8 27 17	0 44 28·31	51 59 11·2	*e*	,, No. 2, p. 67
12 8 29 49	0 44 30·30	51 58 32·0	*i*	,, ,, ,,

Greenwich Mean Solar Time.					R.A. of ☄.	N.P.D. of ☄.		Comp.	References to *Monthly Notices* of R.A.S.		
1892.	d	h	m	s	h m s	° ′ ″					
Nov.	12	8	29	52	0 44 32·38	51 58 51·2		*i*	Vol. liii. No. 2, p. 67.		
	12	8	35	58	0 44 28·17	51 58 47·8		*e*	,,	,,	,,
	14	6	21	19	0 43 45·65	52 9 12·7		*i*	,,	,,	,,
	14	6	37	45	0 43 41·43	52 10 13·7		*d*	,,	,,	,,
	14	6	43	58	0 43 47·03	52 10 22·5		*i*	,,	,,	,,
	14	7	3	14	0 43 44·02	52 10 36·2		*d*	,,	,,	,,
	14	7	27	0	0 43 42·23	52 10 42·4		*d*	,,	,,	,,
	14	7	58	12	0 43 45·94	52 10 36·0		*e*	,,	,,	p. 68
	14	8	2	6	0 43 47·77	52 10 39·0		*e*	,,	,,	p. 67
	14	8	2	6	0 43 48·19	52 10 38·9		*f*	,,	,,	,,
	17	8	50	30	0 42 51·64	52 29 37·4		*d*	,,	,,	p. 68
	18	6	5	48	0 42 38·28	52 35 21·9		*h*	,,	,,	,,
	18	6	19	54	0 42 38·97	52 35 26·0		*d*	,,	,,	,,
	18	7	25	21	0 42 30·97	52 36 24·9		*h*	,,	,,	,,
	18	10	8	2	0 42 31·74	52 36 21·6		*d*	,,	,,	,,
	20	6	20	17	0 42 19·72	52 48 8·7		*c*	,,	,,	,,
	21	7	10	38	0 42 9·72	52 55 8·5		*c*	,,	,,	,,
	21	8	9	47	0 42 9·43	52 56 45·5		*c*	,,	,,	,,
	26	9	2	3	0 42 9·36	53 27 14·6		*b*	,,	,,	,,
	26	9	15	49	0 42 10·06	53 27 26·5		*a*	,,	,,	,,
1893.											
Jan.	20	9	27	41	1 27 2·17	56 21 7·8		*n*	,,	No. 5,	p. 344
	24	9	24	19	1 32 33·70	56 19 34·1		*o*	,,	,,	,,
Feb.	4	7	9	34	1 48 25·84	56 7 54·9		*p*	,,	,,	,,
	4	8	36	20	1 48 35·32	56 8 20·9		*p*	,,	,,	,,
	5	8	49	7	1 50 3·80	56 6 34·2		*p*	,,	,,	,,
	5	9	42	12	1 50 10·24	56 7 18·0		*q*	,,	,,	,,
	6	6	42	56	1 51 27·11	56 4 54·0		*q*	,,	,,	,,
	6	7	14	24	1 51 30·97	56 5 0·5		*q*	,,	,,	,,
	7	8	12	19	1 53 8·37	56 3 15·5		*q*	,,	,,	,,
	8	7	6	17	1 54 34·97	56 1 27·1		*r*	,,	,,	345
	8	7	24	9	1 54 36·79	56 1 12·5		*q*	,,	,,	,,
	10	7	41	29	1 57 44·16	55 58 18·1		*s*	,,	,,	,,
	14	8	47	14	2 4 14·26	55 50 43·5		*t*	,,	,,	,,
	15	9	50	59	2 5 51·84	55 48 31·4		*u*	,,	,,	,,
	16	6	59	23	2 7 16·47	55 46 18·8		*u*	,,	,,	,,
	16	7	5	18	2 7 15·82	55 46 24·4		*v*	,,	,,	,,
Brooks' Comet (*g* 1892).											
1892.											
Dec.	15	14	26	11	13 51 16·50	57 42 23·6		*l*	Vol. liii., No. 3, p. 134		

Improved Mean Places of Comet Comparison Stars.

	Star's Name.	R.A., 1892·0. h m s	N.P.D., 1892·0. ° ′ ″	Authority.
a	W.B. (2) 0, 1013	0 40 58·60	53 33 49·6	Lund Z., 320, 324
b	W.B. (2), 0, 1021	0 41 23·22	53 18 51·3	Lund Z., 335
c	W.B. (2), 0, 1029	0 41 47·88	52 57 30 5	Lund Z., 335
d	Lalande, 1323	0 43 38·27	52 23 3·1	Lund Z., 310, 316, and 2 Paris Observations
e	W.B. (2), 0, 1083	0 44 5·98	51 50 56·7	Lund Z., 320, 324, 348, and 2 Pulkova Observations
f	W.B. (2), 0, 1087	0 44 10·90	51 52 45·6	Lund Z., 366, and 2 Pulkova Observations
g	W.B. (2), 0, 1092	0 44 27·12	51 43 16·7	Lund Z., 91, 98
h	Lalande, 1384	0 45 16·77	52 32 39·3	Lund Z., 348, 366, and 2 Paris Observations
i	Lalande, 1443	0 46 56·60	52 2 16·5	Lund Z., 320, 324, and 1 Paris Observation
k	Lalande, 1444	0 47 1·87	51 32 55·4	Lund Z., 332, 356, and 1 Paris Observation
l	Lalande, 25647*	13 51 8·34	57 36 7·3	Leiden Z., 46, 48

* The Lalande place for 1892·0 should be N.P.D. 57° 35′ 55″·0, not 33′.

	Star's Name.	R.A., 1893·0. h m s	N.P.D., 1893·0. ° ′ ″	Authority.
n	Lalande, 2729	1 24 48·12	56 22 41·9	Leiden Z., 138, 242, 343, 398, and 2 Paris Observations
o	B.D. + 33°, 267	1 32 31·66	56 11 46·5	Leiden Z., 343, 398
p	W.B. (2), I., 1047	1 47 27·90	56 1 50·8	Leiden Z., 396, 398
q	Lalande, 3619	1 52 44·39	56 10 50·2	Leiden Z., 393, 396, and 2 Paris Observations
r	B.D. + 33°, 339	1 55 7·55	55 58 38·5	Leiden Z., 257, 325
s	W.B. (2), I., 1292	1 56 27·37	55 51 18·6	Leiden Z., 260, 337
t	B.D. + 34°, 382	2 3 35·10	55 41 33·1	Leiden Z., 239, 333
u	Lalande, 4092	2 7 41·46	55 52 43·7	Leiden Z., 239, 333, and 1 Paris Observation
v	B.D. + 34°, 396	2 8 0·13	55 35 29·8	Leiden Z., 239, 333

Royal Observatory, Greenwich:
1893 *April* 11.

Observations of Comets made at the Liverpool Observatory, 1892–93.

By William E. Plummer, M.A.

The following observations were made with the 8-inch equatoreal of the Liverpool Observatory, employing either a parallel wire micrometer, or an arrangement similar to that discussed by Colonel Tupman, *Monthly Notices*, vol. xlviii. p. 96, and known as the cross reticule. Of this latter form of micrometer, the observatory possesses two specimens, but neither is quite satisfactory in use. The principal defect seems to arise from the difficulty in destroying parallax, owing partially to the fact that the "cross wires," formed apparently of watch spring, are not in one and the same plane, and this difficulty seems to be aggravated by the low power of the eyepiece. Although all the precautions to which Colonel Tupman calls attention in his paper have been carefully attended to, it is feared that the places of the comets determined with this micrometer are not very trustworthy. They are marked by the abbreviation "Ret." I have in hand a series of observations to enable me to compare the relative accuracy of the determinations derived from the use of the "cross reticule" and the parallel wire micrometer, but the discrepancies in the results obtained on different nights are perplexing and inexplicable.

Observations of Comet VI., 1892.

Greenwich Mean Time of Observation.					$\alpha - *$ R.A.	No. of Comps.	Apparent R.A. of Comet.	$\delta - *$ Declination.	No. of Comps.	Apparent Declination of Comet.	Log. Fact. of Parallax R.A.	Log. Fact. of Parallax δ	Reference to Comp. *
1892.	d	h	m	s	m s		h m s	′ ″		° ′ ″			
Sept.	24	12	39	3	+0 26·49	24	7 9 40·39	+ 2 23·4	6	+28 7 28·9	9·8282*n*	9·8671	*a*
	25	12	34	11	−5 18·32	24	7 12 33·50	+ 2 59·6	6	+27 53 47·8	9·8265*n*	9·8664	*b*
	29	12	58	22	−1 42·27	10	7 24 27·87	− 3 52·4	2	+26 53 9·2	9·8261*n*	9·8540	*c*
Oct.	4	13	16	2	−4 11·45	Ret.	...	− 0 55·2	Ret.	...	9·7988*n*	9·8437	
	16	13	55	20	−4 52·17	Ret.	8 18 22·35	− 1 48·7	Ret.	+20 45 27·3	9·7856*n*	9·8346	*d*
Comet V., 1892.													
Oct.	20	7	15	5	+1 39·62	Ret.	19 48 47·74	− 3 6·9	Ret.	+10 1 32·9	9·2779	9·8378	*e*
	27	7	14	36	−4 19·72	Ret.	20 6 2·97	+ 1 21·2	Ret.	+ 7 30 14·6	9·3278	9·8571	*f*
Comet III., 1892.													
Nov.	11	6	56	22	+0 49·53	20	0 44 58·45	− 1 35·3	4	+38 7 54·6	9·6779*n*	9·5334	*g*
	13	6	34	11	−2 52·70	15	0 44 6·83	− 2 14·8	5	+37 55 55·1	9·7067*n*	9·5545	*h*
	16	7	26	40	−0 34·54	20	0 43 6·66	− 0 7·9	4	+37 37 15·8	9·5175*n*	9·4841	*i*
	17	7	31	16	−0 49·67	24	0 42 51·52	− 6 39·2	5	+37 30 44·9	9·4805*n*	9·4781	*i*
	20	7	29	3	+0 26·90	15	0 42 17·64	+ 8 29·4	5	+37 11 26·1	9·4311*n*	9·4768	*j*
	21	6	55	30	+0 19·02	15	0 42 9·75	+ 2 7·5	5	+37 5 4·3	9·5532*n*	9·5066	*j*
	22	6	19	4	+0 14·75	20	0 42 5·49	− 3 42·4	5	+36 59 14·5	9·6509*n*	9·5448	*j*
	23	6	13	29	+2 41·56	20	0 42 2·82	+ 4 59·3	5	+36 52 58·2	9·6508*n*	9·5468	*l*

Greenwich Mean Time of Observation.					☄−✱ R.A.	No. of Comps.	Apparent R.A. of Comet.	☄−✱ Declination.	No. of Comps.	Apparent Declination of Comet.	Log. Fact. of Parallax R.A.	Log. Fact. of Parallax δ	Reference to Comp. ✱
1892.	d	h	m	s	m s		h m s	′ ″		° ′ ″			
Dec.	10	9	17	46	−1 27·11	20	0 46 26·14	+ 5 9·8	5	+35 14 24·0	9·4875*n*	9·5316	*m*
	10	9	17	46	+4 16·87	20	0 46 26·22	+ 5 0·6	5	+35 14 23·7	9·4875*n*	9·5316	*n*
	16	9	0	24	−0 14·92	15	0 50 7·19	+ 7 21·3	5	+34 46 24·3	9·5030*n*	9·5442	*o*
	16	9	0	24	−1 52·32	15	0 50 7·11	− 0 50·2	5	+34 46 25·8	9·5030*n*	9·5442	*p*
1893.													
Jan.	18	6	58	40	−0 31·68	20	1 24 15·70	+ 1 27·7	5	+33 38 53·9	9·3668*n*	9·5468	*q*
	20	7	59	25	+2 12·15	15	1 26 59·53	...	...	...	9·6195*n*	...	*q*
	20	8	14	11	...	...	...	+ 1 32·4	3	+33 38 58·5	...	9·5979	*q*
	27	6	37	5	+2 22·75	20	1 36 38·59	− 5 29·9	5	+33 42 33·3	9·3754*n*	9·5465	*r*
Feb.	5	7	22	18	−2 45·06	15	1 49 58·42	+ 3 57·8	2	+33 53 16·6	9·6282*n*	9·5962	*s*
	15	8	35	11	−1 54·81	Ret.	2 5 45 66	+ 4 21·6	Ret.	+34 11 46·2	9·7978*n*	9·6944	*t*
	16	8	37	23	−0 18·76	Ret.	2 7 21·71	+ 6 25·9	Ret.	+34 13 50·5	9·8029*n*	9·6993	*t*
	16	8	37	23	−0 12·82	Ret.	2 7 23·02	+12 43·0	Ret.	+34 13 42·9	9·8029*n*	9·6993	*u*
							Comet I., 1893.						
1892.													
Nov.	26	17	59	12	+3 9·20	20	13 6 16·53	+ 5 5·8	4	+16 9 3·7	9·6294*n*	9·8106	*v*
	30	16	4	30	−2 15·64	20	13 12 45·31	+ 4 37·6	4	+18 24 28·0	9·7713*n*	6·8406	*x*
Dec.	15	17	49	16	−0 34·13	Ret.	13 51 51·05	− 8 1·8	Ret.	+32 28 37·0	9·6433*n*	9·6259	*y*
	28	17	26	5	+3 12·10	20	15 33 50·92	− 3 57·9	5	+55 35 16·2	9·9472*n*	9·2612	*z*
	28	17	26	5	+7 41·99	20	15 33 51·27	+ 1 50·6	5	+55 35 21·4	9·9472*n*	9·2612	*aa*

Mean Places of Stars of Comparison.

Star's Designation or Authority.	Mean R.A. Beginning of Year.	Corr. to Apparent Place.	Mean Decl. Beginning of Year.	Corr. to Apparent Place.	Letter of Ref.
	h m s	s	° ′ ″	″	
53 Geminorum	7 9 12·24	+1·66	+28 5 6·0	− 0·5	*a*
Paris Catalogue, 9059	7 17 50·19	+1·63	+27 50 45·7	+ 2·5	*b*
Bonn, vol. xi. +27°, No. 1410	7 26 8·43	+1·71	+26 56 59·4	+ 2·2	*c*
Paris Catalogue, 10415	8 23 12·68	+1·84	+20 47 16·2	− 0·2	*d*
Ast. Nach., No. 3128, p. 130	19 47 6·60	+1·52	+10 4 30·9	+ 8·9	*e*
M_1 23665	20 10 21·11	+1·58	+ 7 28 44·2	+ 9·2	*f*
Lund Zones, No. 330	0 44 5·98	+2·96	+38 9 3·7	+26·2	*g*
Paris Catalogue, 1102	0 46 56·59	+2·94	+37 57 43·5	+26·4	*h*
Lund Zones	0 43 38·28	+2·92	+37 36 57·0	+26·7	*i*
Lund Zones, No. 335	0 41 47·88	+2·86	+37 2 29·6	+27·1	*j*
Lund Zones, No. 73, 94	0 39 18·46	+2·74	+36 47 31·3	+28·3	*l*
Leiden Zones, No. 235	0 47 50·53	+2·72	+35 8 46·0	+28·2	*m*
Leiden Zones, No. 324	0 42 6·70	+2·65	+35 8 55·0	+28·1	*n*
Leiden Zones, No. 324	0 50 19·46	+2·65	+34 38 35·0	+28·0	*o*
$W_2 O^h$ No. 1279	0 51 56·78	+2·64	+34 46 47·9	+28·0	*p*
Leiden Zones, No. 343	1 24 48·24	−0·86	+33 37 18·0	+ 8·2	*q*
Leiden Zones, No. 903	1 34 16·76	−0·92	+33 47 55·1	+ 8·1	*r*
Leiden Zones, No. 396	1 52 44·43	−0·95	+33 49 10·6	+ 8·2	*s*
Leiden Zones, No. 239	2 7 41·50	−1·03	+34 7 16·7	+ 7·9	*t*
Paris Observations, 1882	2 7 36·87	−1·02	+34 0 52·0	+ 7·7	*u*
Romberg, 6099	13 3 6·04	+1·29	+16 4 13·4	−15·5	*v*
$Armagh_2$, No. 1553	13 14 59·61	+1·34	+18 20 8·3	−17·9	*x*
W. B., xiii. No. 1120	13 52 23·77	+1·41	+32 37 4·1	−25·3	*y*
Hels. Zones, 86, 87	15 30 38·89	−0·07	+55 39 42·1	−28·0	*z*
O. A., No. 15423	15 26 9·28	0·00	+55 33 59·1	−28·3	*aa*

Liverpool Observatory:
1893 *April* 13.

Galactic Longitudes and Latitudes of the brighter Stars in a Zone of the Heavens containing the Milky Way. By A. Marth.

(*Continued from page* 109.)

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °
180·03	− 9·04	5·6	6·2		Monocerotis	6	8	41	− 4 32·1
180·25	+ 1·45	...	cum.		,,	8m·5 6	45	31	+ 0 30·6
180·45	− 9·02	6·0	6·3		,,	6	9	35	− 4 52·6
180·53	−24·60	5·2	5·7	7	ν Leporis	5	14	25	−12 26·4
180·53	+ 7·73	5·5	5·9		Monocerotis, Canis min.	7	8	3	+ 3 18·9
180·67	−12·34	5·0	5·8		Orionis, Monocerotis	5	58	24	− 6 42·3
181·31	− 0·11	...	6·2		Monocerotis	6	42	14	− 1 11·2
181·33	−25·07	4·3	4·1	6	λ Leporis	5	14	3	−13 18·1
181·38	−17·33	2·2	2·3	53	κ Orionis	5	42	4	− 9 42·8
181·46	−10·60	5·0	5·9		Monocerotis	6	6	1	− 6 31·5
181·58	− 9·81	4·0	4·3	5	,,	6	9	0	− 6 14·4
181·81	+14·23	0·5	1·2	10	α Can. min. (Procyon)	7	33	1	+ 5 31·9
181·83	− 6·23	5·0	5·4	10	Monocerotis	6	22	2	− 4 41·4
181·89	+ 1·31	5·2	5·9		,,	6	48	19	− 0 58·7
182·08	−20·61	6·0	6·5		Orionis, Leporis	6	31	33	−11 51·0
182·26	− 1·37	...	6·1		Monocerotis	6	43	14	− 2 8·3
182·54	−24·55	5·1	5·7	8	Leporis	5	18	1	−14 2·5
182·63	−14·81	5·1	5·7	2	Monocerotis	5	53	23	− 9 34·1
182·80	+11·92	5·6	6·2	8	δ_2 Canis minoris	7	26	54	+ 3 32·7
182·82	+24·20	3·8	3·5	17	β Cancri	8	10	0	+ 9 33·2
183·26	+ 5·41	...	6·0	21	Monocerotis	7	5	16	− 0 6·3
183·28	− 4·57	5·2	5·9		,,	6	30	41	− 5 6·8
183·34	− 5·80	5·7	6·0		,,	6	26	31	− 5 46·9
183·49	+ 5·42	4·0	4·6	22	,,	7	5	44	− 0 17·7
183·54	− 9·50	5·1	5·9	7	,,	6	13	56	− 7 46·4
183·89	+11·01	5·1	5·9	7	δ_1 Canis minoris	7	25	52	+ 2 10·4
183·91	−14·70	4·8	5·6	3	Monocerotis	5	56	12	−10 36·0
183·93	− 7·14	3·9	4·1 tr.	11	,,	6	23	0	− 6 57·4
184·01	−13·75	5·9	6·4		,,	5	59	47	−10 14·2
184·84	−10·43	5·7	6·0		,,	6	13	8	− 9 20·6
184·92	+18·80	5·6	6·0		Canis minoris	7	54	53	+ 5 12·5
185·29	− 7·03	5·6	6·0		Monocerotis	6	26	4	− 8 4·4
185·64	+ 1·63	4·8	5·5	19	,,	6	56	57	− 4 4·0

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h m s	δ 1880. ° ′
186·10	−19·12	5·6	5·8		Leporis		5 44 10	−14 31·2
186·12	−19·85	3·7	3·6	14	ζ „		5 41 31	−14 52·1
186·52	+15·19	5·0	5·7	13	ζ Canis minoris		7 45 29	+ 2 4·3
186·55	+ 3·21	5·1	5·4	20	Monocerotis		7 4 16	− 4 3·1
186·58	−17·51	3·7	3·8	16	η Leporis		5 50 56	−14 11·5
186·73	+ 1·35	...	6·2		Monocerotis		6 58 11	− 5 8·9
186·81	+ 0·68	5·4	5·6		„		6 56 3	− 5 33·1
186·90	+ 8·50	5·7	6·0		„		7 23 15	− 1 39·6
186·97	+16·86	5·3	6·0	14	Canis minoris		7 52 7	+ 2 32·6
187·28	−11·00	5·3	6·1		Monocerotis, Canis		6 15 49	−11 43·2
187·38	−10·29	5·5	5·6		„ „		6 18 34	−11 28·0
187·39	− 5·33	5·4	5·7		„		6 36 13	− 9 3·2
187·39	+17·76	4·6	4·9	1	Hev. Canis minoris		7 56 1	+ 2 39·8
187·45	−24·22	2·7	2·7	11	α Leporis		5 27 26	−17 54·6
187·46	− 2·28	6·1	6·6		Monocerotis		6 44 56	− 7 54·1
187·93	− 4·02	5·3	5·6		„		6 41 53	− 8 52·1
188·39	−13·13	4·8	5·5		Canis		6 10 15	−13 40·8
188·41	−15·75	4·6	5·2	18	θ Leporis		6 0 43	−14 55·5
188·47	−14·86	5·7	6·0		„		6 4 8	−14 33·9
188·78	− 4·76	5·5	6·1		Canis, Monocerotis		6 40 58	− 9 58·8
188·96	− 0·97	...	6·2		Monocerotis		6 54 38	− 8 14·4
189·00	− 9·15	5·3	5·6		Canis		6 25 49	−12 18·5
189·29	− 0·49	...	cum.		Monocerotis	$7^{m}\cdot7$	6 57 0	− 8 16·8
189·33	−22·24	6·0	6·0		Leporis		5 38 7	−18 36·8
189·58	+ 4·97	5·8	6·2		Monocerotis		7 16 32	− 5 45·3
189·72	−16·70	4·9	5·5	17	Leporis		5 59 38	−16 28·7
189·84	+ 9·11	5·1	5·7	25	Monocerotis		7 31 19	− 3 50·7
190·59	+15·63	4·9	5·2	28	„		7 55 7	− 1 3·7
191·08	−14·37	5·9	6·5		Canis		6 10 47	−16 34·7
191·37	− 4·08	4·2	4·4	14	θ „		6 48 37	−11 53·4
191·44	−14·13	5·1	5·8		„		6 12 21	−16 46·3
191·48	− 8·28	5 0	5·3		„		6 33 48	−14 2·4
192·23	− 1·06	5·1	6·0		„		7 1 3	−11 6·6
192·34	+ 1·09	5·9	6·3		Monocerotis		7 8 47	−10 6·7
192·42	+14·13	5·1	5·6	27	„		7 53 44	− 3 21·2
192·53	−17·30	5·5	5·9	19	Leporis		6 2 28	−19 9·2
192·61	− 6·80	4·9	5·5	11	Canis		6 41 23	−14 17·9
192·84	− 7·16	5·3	5·7		„		6 40 32	−14 40·2

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h m s	δ 1880. ° ′
192·98	−21·49	4·0	3·7	15 δ Leporis	5 46 10	−20 53·6
193·00	+16·38	4·5	4·9	29 Monocerotis	8 2 34	− 2 38·1
193·02	+11·75	5·7	6·4	,,	7 46 52	− 5 7·2
193·04	−13·58	2·0	2·2	2 β Canis	6 17 25	−17 53·9
193·29	+ 9·61	5·9	6·1	Monocerotis	7 40 10	− 6 28·7
193·29	−23·59	3·8	3·5	13 θ Leporis	5 39 28	−22 29·3
193·36	− 4·65	5·2	5·5	18 μ Canis	6 50 37	−13 53·4
193·49	− 6·70	5·3	5·8	,,	6 43 31	−15 0·6
193·92	+ 4·82	var.	5·9−8·0	U Monocerotis	7 25 4	− 9 31·6
194·21	+ 4·24	...	6·2	,,	7 23 40	−10 4·8
194·40	−15·41	5·1	5·8	Canis	6 13 3	−19 54·7
194·42	− 8·22	−1·4	0·1	α ,, (Sirius)	6 39 52	−16 33·2
194·98	−10·49	4·7	4·9	8 ν_3 ,,	6 32 37	−18 8·1
195·06	+ 7·16	4·2	4·0	26 Monocerotis	7 35 31	− 9 16·3
195·08	+ 3·29	5·8	6·3	,, , Canis	7 22 13	−11 18·9
195·20	−11·01	...	6·4	6 ν_1 Canis	6 31 8	−18 33·8
195·39	−15·68	5·4	6·2	,,	6 13 51	−20 52·6
195·65	− 3·81	4·1	4·5	23 γ ,,	6 58 20	−15 27·4
195·76	−18·43	5·5	5·8	Leporis	6 3 55	−22 24·4
195·77	−11·22	4·2	4·1	7 ν_2 Canis	6 31 27	−19 9·3
195·87	+22·19	5·6	6·4	Monocerotis. Hydræ	8 27 57	− 1 44·6
195·92	+ 9·21	5·8	6·2	,,	7 44 25	− 8 52·9
195·93	+19·34	...	6·2	,, . 1 Hydræ	8 18 36	− 3 21·8
196·01	− 6·11	4·5	4·9	20 ι Canis	6 50 47	−16 54·0
196·08	+15·39	cum. VI 22		8m	8 5 39	− 5 39·7
196·15	+15·96			Monoc., Hydræ 8m·5	8 7 45	− 5 24·8
196·36	+16·02			8m	8 8 22	− 5 32·3
196·16	−18·40	5·7	5·9	Leporis	6 4 46	−22 44·3
196·17	−19·22	5·4	5·8	,, 6m	6 1 32	−23 5·9
...	...			,, 7m	6 1 51	−23 4·9
196·22	+19·48	3·9	3·8	30 Monocerotis, C Hydræ	8 19 40	− 3 31·0
196·41	+19·60	...	6·2	,, , 2 ,,	8 20 28	− 3 35·6
196·87	− 2·90	6·0	6·6	Canis	7 4 9	−16 2·5
197·11	− 1·18	5·2	5·9	,,	7 10 48	−15 22·5
197·44	− 7·64	5·5	6·1	,,	6 48 4	−18 53·2
197·61	+14·43	5·3	5·7	Monocerotis, Hydræ	8 5 43	− 7 25·0
198·17	+12·57	5·8	6·5	,,	8 0 41	− 8 54·1
198·17	− 9·99	cum. neb. Mess. 14		Canis 7m·6	6 40 48	−20 39·0

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h m s	δ 1880. ° ′
198°·20	− 0°·93	var.	5·9 − 6·7		R Canis		7 14 2	−16 10·3
198·21	+ 7·15	5·4	5·9	5	Puppis		7 42 20	−11 54·0
198·35	+ 3·01	5·0	5·2		,,		7 28 17	−14 15·9
198·52	− 8·16	4·4	5·3	15	Canis		6 48 22	−20 4·6
198·63	+ 3·48	cum. VIII. 38			Puppis	6m·0	7 30 33	−14 13·7
198·69	+ 3·61				,,	7m·0	7 31 5	−14 13·0
198·67	+ 0·25	4·9	6·0		Canis		7 19 15	−15 58·0
198·68	− 7·69	4·4	4·9	19 π	,,		6 50 25	−19 59·1
198·85	− 7·94	5·9	6·5	17	,,		6 49 52	−20 15·2
198·94	−21·19	5·0	5·5		Columbæ, Leporis		5 58 25	−26 17·1
198·98	−13·24	4·4	4·8	5	ξ_2 Canis		6 30 2	−22 52·2
199·06	−14·10	4·2	4·5	4	ξ_1 ,,		6 26 51	−23 20·0
199·77	+ 6·16	5·2	5·5	4	Puppis		7 40 25	−14 16·4
199·84	+ 3·97	5·2	5·4		,,		7 34 54	−14 59·2
199·89	−19·63	5·9	6·4		Columbæ, Leporis		6 6 25	−26 27·4
199·97	−20·01	6·0	6·6		,, ,,		6 4 59	−26 40·8
200·13	−12·64	5·8	6·6		Canis		6 34 37	−23 35·3
200·15	+ 7·03	5·5	5·7	9	Puppis		7 46 13	−13 34·9
200·27	−16·66	5·8	6·0		Canis		6 19 3	−25 30·8
200·40	− 0·10	5·6	6·2		,,		7 21 47	−17 37·5
200·49	−20·03	5·8	6·0		Columbæ, Leporis		6 5 48	−27 7·7
200·80	− 1·69	4·9	5·7		Canis		7 16 56	−18 47·4
200·85	−16·11	6·0	6·5		,,		6 22 21	−25 46·6
201·03	+ 6·62	5·6	6·1	10	Puppis		7 46 47	−14 32·3
201·04	− 9·35	5·2	5·9		Canis		6 50 44	−22 47·2
201·17	− 4·77	5·6	6·3		,,		7 6 31	−20 41·1
201·25	+19·22	5·7	6·1		Monocerotis, 3 Hydræ		8 29 37	− 7 34·2
201·55	−10·75	6·2	6·6 cum.		Canis		6 44 45	−23 56·3
201·85	+21·31	4·8	4·9	31	Monocerotis, F Hydræ		8 37 47	− 6 48·2
201·90	− 9·77	6·4	7·2		Canis		6 49 13	−23 46·7
201·97	+11·52	4·6	5·2	19	Puppis		8 5 38	−12 34·3
202·12	− 9·91	4·0	3·9	16 o_1	Canis		6 49 9	−24 2·1
202·48	+ 0·35	...	6·2		Puppis		7 28 2	−19 9·2
202·63	+10·92	...	6·0	18	,,		8 5 6	−13 26·8
202·69	+13·13	6·0	6·5		,,		8 12 42	−12 13·6
202·70	+ 4·80	5·7	5·7	6	,,		7 44 16	−16 55·4
202·78	− 7·96	3·0	3·4	24 o_2	Canis		6 58 1	−23 39·6
202·90	− 9·43	5·2	5·9		,,		6 52 37	−24 28·5

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h	m	s	δ 1880. °	′	″
°	°	m	m									
203·01	−16·20	5·7	6·1		Canis		6	26	1	−27	41	2
203·15	+ 0·88	...	6·2		Puppis		7	31	25	−19	26	2
203·38	−15·85	5·7?	8·5		Canis	8m·5	6	28	11	−27	51	1
203·70	− 9·60	5·4	6·0		„		6	53	41	−25	15	2
203·80	− 9·00	6·0	6·0		„		6	56	10	−25	2	8
203·84	+14·84	5·8	5·9		Puppis, Monocerotis		8	21	2	−12	8	5
204·22	−19·24	3·0	3·2	1	ζ Canis		6	15	42	−30	0	7
204·52	+ 9·29	...	6·0		Puppis		8	3	59	−15	53	8
204·67	+10·32	5·1	5·7	20	„		8	7	49	−15	25	7
204·87	− 2·81	5·4	5·7		Canis		7	21	54	−22	50	6
204·93	+ 6·06	4·6	5·2		Puppis		7	54	29	−18	4	3
205·04	− 1·01	4·5	5·2		„		7	28	55	−22	2	3
205·15	− 2·21	4·8	5·7		„		7	24	46	−22	46	6
205·18	− 5·20	4·8	5·6	29	Canis		7	13	41	−24	20	5
205·52	− 5·39	4·3	4·6	30	„		7	13	44	−24	44	2
205·63	− 8·11	1·8	2·1	25	δ „		7	3	31	−26	12	2
205·74	+13·29	6·0	6·3		Puppis		8	20	21	−14	32	4
205·78	+17·51	5·2	5·4	6	Hydræ		8	34	20	−12	3	1
206·07	− 1·57	5·2	5·7 *d*		π Puppis		7	29	15	−23	12	8
206·24	− 6·96	4·5	5·4	27	Canis		7	9	22	−26	8	8
206·28	+ 3·06	...	6·2		Puppis		7	46	29	−20	52	1
206·30	−10·16	3·5	3·6	22	σ Canis		6	56	56	−27	45	8
206·41	−15·58	5·8	5·9		„		6	35	7	−30	21	4
206·67	− 7·05	3·7	4·2	28	ω „		7	9	56	−26	33	9
206·82	− 8·28	5·4	6·3		„		7	5	30	−27	17	8
206·92	−11·24	1·5	1·8	21	ε „		6	53	55	−28	48	6
206·95	+ 7·51	4·2	5·1	16	Puppis		8	3	40	−18	53	7
206·96	− 6·17	5·4	6·0		Canis		7	13	58	−26	22	0
206·99	− 2·44	5·6	6·7		Puppis		7	28	9	−24	27	2
207·24	−17·61	5·7	6·0 *d*		Canis		6	28	9	−31	56	5
207·37	−18·37	4·1	4·7		λ „		6	23	43	−32	30	3
207·37	+10·96	5·9	5·9		Puppis		8	16	28	−17	12	3
207·44	−14·92	5·2	5·7	10	Canis		6	39	54	−30	56	9
07·50	+ 0·22	...	cum. Mess. 93		Puppis	8m	7	39	13	−23	26	2
207·66	+18·09	4·4	4·4	12	Hydræ		8	40	42	−13	6	6
207·68	−20·20	4·1	3·9		δ Columbæ, 3 Canis		6	17	44	−33	22	6
207·80	+ 6·43	5·1	5·9		Puppis		8	2	0	−20	12	5
207·84	− 7·25	4·9	5·4		Canis		7	11	46·	−27	40	2

Galactic Long.	Lat.	Magn. H.P.	U.A.		Star.	α 1880. h m s	δ 1880. ° ′
		m	m				
208·00	−16·75	...	5·7		Canis	6 33 18	−32 14·3
208·07	−17·51	5·3	6·1		„	6 30 8	−32 37·4
208·16	− 1·79	4·3	5·4	*m*	Puppis	7 33 18	−25 5·6
208·25	−20·76	...	6·0		Columbæ	6 16 16	−34 5·5
208·33	− 0·22	5·4	6·4		Puppis	7 39 31	−24 23·4
208·57	− 5·90	...	6·1		Canis	7 18 39	−27 36·2
208·66	+ 3·11	4·3	4·9	11	Puppis	7 51 42	−22 33·7
208·86	− 4·99	4·7	5·0 *d*		Canis	7 11 33	−23 6·2
208·92	−21·90	...	4·8	κ	Columbæ	6 12 17	−35 6·1
208·92	+15·74	5·0	.5·3	*q*	Hydræ	8 36 9	−15 30·8
209·01	+ 3·30	5·2	5·9	12	Puppis	7 53 57	−22 59·1
209·07	+ 0·58	3·4	3·5	7 ξ	„ , ξ Argus	7 44 15	−24 33·6
209·29	−14·51	3·9	4·0	13 κ	Canis	6 45 21	−32 22·2
209·39	+ 9·46	5·4	6·0		Puppis	8 16 22	−19 41·7
209·45	− 2·45	3·9	4·0 *d*	*k*	„	7 33 55	−26 31·9
209·53	− 1·46	5·8	6·5		„	7 37 51	−26 4·0
209·83	+ 0·23	4·7	5·3	o	„	7 43 6	−25 38·4
209·91	− 6·52	2·4	2·9	31 η	Canis	7 19 21	−29 4·2
210·19	− 8·85	...	6·1		„	7 10 43	−30 28·7
210·37	− 3·92	4·4	5·3	*p*	Puppis	7 30 34	−28 6·3
...	...	...	7·7 } 5·6		Monocerotis, Pyxidis	8 26 0	−19 6·1
210·38	+11·60	5·4	5·7 }		„ „	8 26 7	−19 10·4
210·93	+ 4·32	2·9	3·2	15	Puppis, ρ Argus	8 2 26	−23 57·6
211·11	−15·12	...	5·4		„	6 46 30	−34 13·6
211·36	− 2·42	5·0	5·0	1	„	7 38 42	−28 7·6
211·41	−19·06	...	5·9		Columbæ	6 29 37	−36 8·6
211·53	+ 7·54	5·8	6·0		Puppis	8 15 14	−22 32·8
211·58	−13·61	...	5·4	*t*	„	6 54 2	−33 57·0
211·75	+18·81	5·9	6·4		Hydræ	8 53 6	−15 40·8
211·85	− 2·66	4·2	4·2	3 *l*	Puppis	7 38 59	−28 40·1
212·07	−18·98	...	6·1		Columbæ	6 31 14	−36 41·0
212·08	− 8·03	5·4	5·9		Puppis, Canis	7 18 25	−31 41·6
212·08	− 6·13	4·6	5·3		„	7 26 3	−30 42·7
212·17	− 7·66	...	5·6		Canis	7 20 8	−31 34·4
212·34	+ 8·22	5·5	5·9		Puppis	8 19 42	−22 46·0
212·39	− 8·07	...	5·8		Canis	7 18 59	−31 58·3
212·71	−19·89	...	5·8		Columbæ	6 28 15	−37 36·4
212·94	−15·76	...	6·2		Puppis	6 47 29	−36 5·1

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h m s	δ 1880. ° ′
213·08	+ 7·71	5·5	5·8	Puppis	8 19 53	−23 39·5
213·81	− 4·64	var.	6·5−7·5	R „	7 36 13	−31 23·0
213·99	+11·11	5·1	5·6	Pyxidis	8 33 53	−22 15·3
214·14	−17·32	...	5·3	*x* Puppis	6 43 15	−37 47·9
214·63	+ 5·92	5·7	6·5	„	8 17 46	−25 57·9
214·65	+ 8·82	5·9	6·4	Pyxidis, Mali	8 27 54	−24 11·9
214·66	− 0·89	4·8	5·5	Puppis	7 52 53	−30 0·8
215·20	+19·28	...	6·2	Hydræ	9 3 32	−17 49·4
215·60	−11·41	...	5·6	Puppis	7 12 33	−36 22·7
215·87	−11·22	...	5·3 } 4·8	ν_1 „	7 14 2	−36 31·0
...	...	...	5·4 }	ν_2 „	7 14 22	−36 31·4
216·09	−11·59	...	2·7	π „ , π Argus	7 12 54	−36 53·0
216·26	− 6·99	...	4·8	*f* „	7 32 56	−34 42·0
216·53	− 5·15	...	6·0	„	7 41 7	−33 56·3
216·64	+ 8·64	5·0	5·6	η Pyxidis, *g* Mali	8 32 45	−25 50·1
216·76	+ 7·85	5·7	6·5	„ „	8 30 23	−26 25·8
216·82	+18·83	5·7	6·4	Hydræ	9 6 29	−19 15·5
217·08	− 8·30	...	6·0	Z Puppis	7 29 31	−36 4·7
217·11	+10·58	5·8	6·5	Pyxidis, Mali	8 40 38	−24 57·1
217·38	− 1·05	...	5·8	Puppis	7 59 36	−32 20·2
217·65	−14·21	...	5·3	A „	7 4 49	−39 27·8
217·68	− 4·26	...	5·7	„	7 47 47	−34 24·3
217·73	− 7·54	...	6·3	„	7 34 23	−36 13·4
217·83	− 6·51	...	6·2	„	7 39 0	−35 45·9
217·93	− 6·38	...	6·2	„	7 39 47	−35 46·7
218·13	−12·34	...	5·8	F „	7 14 28	−38 59·5
218·57	−20·97	...	3·5	*v* „	6 34 5	−43 5·5
218·65	−15·06	...	6·2	„	7 3 11	−40 42·4
218·73	−14·01	...	5·7	E „	7 8 17	−40 17·8
218·77	−10·36	...	5·9	*y* „	7 24 55	−38 33·9
218·87	− 4·57	...	6·1	„	7 49 44	−35 33·8
219·15	− 5·03	...	6·0	„	7 48 39	−36 3·2
219·36	− 8·35	...	5·4	d_1 „	7 35 14	−38 1·8
219·48	+ 6·87	4·9	5·4	ζ Pyxidis, *f* Mali	8 34 44	−29 8·1
219·61	+ 9·88	4·3	4·4	γ „ *c* „	8 45 26	−27 15·9
219·67	− 7·20	...	3·6 cum	*c* Puppis	7 40 59	−37 40·7
219·74	−16·20	...	5·5	C „	7 0 14	−42 9·6
219·75	− 8·17	...	6·2	„	7 37 3	−38 15·2

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880 h	m	s	δ °	′
219·80	+ 1·63	...	5·7	*w* Puppis	8	16	39	−32	40·4
220·26	+ 3·70	...	6·1	Pyxidis, Mali	8	25	40	−31	45·4
220·27	+ 9·26	5·8	6·4	„ „	8	45	18	−28	10·2
220·31	+ 10·73	4·8	5·4	δ „ *d* „	8	50	23	−27	13·2
220·36	− 7·12	...	5·9	Puppis	7	43	10	−38	12·9
220·86	+ 14·02	4·8	4·9	κ Pyxidis, Mali	9	2	47	−25	22·5
220·87	+ 8·65	5·9	6·5	„ „	8	45	0	−29	1·0
220·95	− 16·75	...	5·8*d*	Puppis	7	0	17	−43	26·5
221·12	− 1·37	...	5·3	*r* „	8	8	58	−35	32·3
221·22	− 6·46	...	4·9	*b* „	7	48	24	−38	33·2
221·33	− 0·31	...	6·2	„	8	13	42	−35	4·7
221·41	+ 19·62	5·0	5·1	G Hydræ	9	21	49	−21	49·1
221·48	+ 21·41	5·2	5·9	„	9	27	41	−20	35·1
221·51	− 1·54	...	5·9	Puppis	8	9	28	−35	57·6
...	...	...	7·0 (5·4)	„	8	9	28	−35	58·7
222·06	− 9·01	...	5·7	„	7	39	37	−40	38·5
222·27	− 8·15	var.	6·5−7·2	T „	7	44	2	−40	21·2
222·31	− 5·59	...	5·9	„	7	55	14	−38	58·1
222·34	− 1·00	...	4·7	*q* „	8	14	4	−36	17·3
222·53	− 0·44	...	5·9	„	8	16	49	−36	6·2
222·62	− 7·45	...	4·0	*a* „	7	48	6	−40	16·0
222·68	− 15·65	var.	3·5−6·3	L_2 „	7	9	53	−44	26·7
222·81	− 12·52	...	3·5	σ „ „ σ Argus	7	25	25	−43	3·5
222·82	− 20·22	...	5·4	„	6	46	31	−46	29·3
222·82	+ 5·18	...	3·8	*a* Pyxidis, *a* Mali	8	38	46	−32	45·3
222·89	+ 20·24	5·8	6·3	Hydræ	9	27	58	−22	20·3
223·12	+ 16·12	4·9	5·2	θ Pyxidis, *h* Mali	9	16	11	−25	27·3
223·15	− 15·93	...	5·3	L_1 Puppis	7	9	38	−44	58·5
223·35	− 5·33	...	2·5	ζ „ „ ζ Argus	7	59	22	−39	39·9
223·37	+ 6·44	...	5·8	Pyxidis, Mali	8	44	59	−32	20·0
223·71	− 22·57	...	5·3*d*	Puppis	6	35	26	−48	6·8
223·89	− 3·89	...	4·8	h_1 „	8	7	4	−39	15·7
223·97	− 3·26	...	4·4	β Pyxidis, *b* Mali	8	35	24	−34	53·0
224·34	− 6·20	...	6·2	Puppis	7	58	37	−40	58·5
224·50	+ 11·22	5·4	6·0	ε Pyxidis, *e* Mali	9	4	51	−29	52·6
224·59	− 16·72	...	4·8	I Puppis	7	9	8	−46	33·6
224·78	− 3·89	...	4·8	h_2 „	8	9	47	−39	58·9
224·82	+ 20·94	4·6	5·2	Hydræ	9	35	49	−23	2·8

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h	m	s	δ 1880. °	′	″
224°·84	−16°·41	...	m 6·2	Puppis	7	11	19	−46	38′	4
224·89	−16·15	...	6·1	„	7	12	48	−46	33	7
224·98	+16·99	5·7	6·0	Antliæ	9	24	35	−26	3	9
225·24	+20·85	4·9	5·4	Hydræ	9	36	49	−23	22	6
225·28	+19·02	6·0	6·4	„	9	31	36	−24	45	6
225·31	−24·56	...	5·5	Puppis	6	26	52	−50	9	3
225·32	−20·01	...	5·5	„	6	53	4	−48	33	8
225·48	+14·34	4·9	5·3	λ Pyxidis, Mali	9	18	1	−28	19	3
225·59	− 8·30	...	6 } 5·9	Puppis	7	53	2	−43	10	8
...	...	...	7·2 }	„	7	53	12	−43	9	7
225·68	−11·29	...	5·6	„	7	39	14	−44	52	1
226·03	+14·91	6·0	6·5	Pyxidis, Mali	9	21	31	−28	16	1
226·14	− 8·58	...	5·7	N Puppis	7	53	25	−43	47	3
226·17	−17·04	...	5·0	„	7	11	19	−48	3	8
226·53	−17·90	...	5·6	„	7	7	34	−48	44	4
226·65	− 5·83	...	5·3	„	8	7	23	−42	37	8
226·68	−19·19	...	5·3	H „	7	0	46	−49	24	6
226·81	−21·65	...	3·2	τ „ , τ Argus	6	46	57	−50	28	3
226·84	+15·86	var.	6·7−7·3	S Antliæ	9	27	3	−28	6	0
227·24	− 9·58	...	5·6	O Puppis	7	54	5	−45	15	3
227·32	−10·98	...	4·3	P „	7	45	35	−46	4	3
227·36	−11·36	...	5·9	„	7	43	54	−46	18	7
227·39	− 6·75	...	5·9	Velorum	8	5	38	−43	46	2
227·56	− 3·20	...	6·0	Puppis	8	21	40	−41	45	7
227·64	−26·12	...	0·4	α Argus (Canopus)	6	21	17	−52	37	8
227·80	+ 0·11	...	6·0	Velorum	8	35	55	−39	50	3
227·84	−11·47	...	5·1	Q Puppis	7	44	46	−46	46	5
228·04	− 7·83	...	5·7	Velorum, Puppis	8	2	49	−44	55	2
228·26	−20·33	...	5·8	Carinæ	6	57	57	−51	13	9
228·29	+18·25	4·9	5·1	θ Antliæ	9	38	51	−27	13	3
228·33	−13·70	...	6·0	Puppis	7	34	55	−48	19	7
228·41	−14·04	...	6·1	„	7	33	22	−48	33	7
228·45	−24·59	...	4·8	N Carinæ	6	32	20	−52	52	7
228·84	+21·09	5·1	5·3	Hydræ	9	48	46	−25	22	1
228·86	+13·23	...	6·1 *d*	ζ_1 Antliæ	9	25	38	−31	21	7
228·97	+13·36	...	6·3	ζ_2 „	9	26	24	−31	20	6
229·00	+ 1·42	...	6·2	k Velorum	8	45	11	−39	52	4
229·18	−11·29	...	4·5	J Puppis	7	49	46	−47	47	4

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.		α 1880. h	m	s	δ 1880. °	′	″
229·57	− 2·02	...	4·6	*e* Velorum		8	33	26	−42	34	2
229·62	−16·53	...	5·7	Carinæ		7	23	17	−50	46	6
229·86	−22·68	...	4·8	A „		6	47	15	−53	29	0
230·00	− 4·26	...	5·5*d*	Velorum		8	25	25	−44	19	4
230·05	− 8·61	...	3 cum.	γ „	, γ Argus	8	5	50	−46	59	0
30·10	+13·92	...	6·2	Antliæ		9	32	0	−31	38	4
230·11	− 0·86	...	4·4	*d* Velorum		8	40	7	−42	12	9
230·16	− 7·83	...	5·8	„		8	9	51	−46	37	7
230·22	−17·80	...	5·9	Carinæ		7	17	43	−51	51	6
230·31	− 0·50	...	cum.	Velorum	$7^{m}\cdot5$	8	42	15	−42	7	6
230·42	− 0·20	...	cum.	„	$6^{m}\cdot9$	8	43	49	−42	1	3
230·42	+ 7·10	...	5·1	*k* „		9	10	57	−36	54	8
230·48	−12·13	...	5·0	Puppis, Velorum		7	49	41	−49	18	1
230·57	− 8·91	...	5·9	Velorum		8	6	4	−47	35	2
230·61	−11·21	var.	4·4 − 5·2	Puppis, Velorum		7	54	47	−48	55	2
231·03	+ 2·23	...	5·2	*w* Velorum		8	55	37	−40	47	2
231·14	− 9·41	...	6·2	„		8	5	35	−48	19	9
231·21	+ 6·25	...	5·5	*l* „		9	10	53	−38	4	2
231·33	−11·47	...	6·2 *d*	Puppis, Velorum		7	55	49	−49	39	0
231·41	+10·01	...	5·0	*e* Antliæ		9	24	18	−35	25	6
231·63	+ 1·99	...	6·2	Velorum		8	56	53	−41	23	6
231·86	−15·23	...	5·5	Q Carinæ		7	32	42	−52	16	0
231·93	− 2·99	...	5·9	Velorum		8	37	52	−44	58	9
231·98	+ 5·83	...	5·8	„		9	12	15	−38	53	9
232·28	− 7·50	...	5·4	B „		8	18	50	−48	6	3
232·49	− 6·29	...	6·0	A „		8	25	17	−47	31	7
232·73	− 3·96	...	4·1	*b* „		8	36	39	−46	13	3
232·76	− 1·88	...	5·7	*g* „		8	45	39	−44	51	7
232·81	− 9·68	...	6·0	„		8	10	6	−49	49	9
232·83	− 2·71	...	6·2	„		8	42	25	−45	28	4
232·87	− 2·86	...	4·1	*a* „		8	41	57	−45	36	2
233·18	− 4·20	...	5·2	*n* „		8	37	17	−46	53	4
233·62	+ 1·78	...	2·5	λ „	λ Argus	9	3	35	−42	56	9
233·73	−13·38	...	3·7	χ Carinæ,	χ „	7	53	44	−52	39	7
233·76	− 2·59	...	5·6	*f* Velorum		8	46	29	−46	4	9
233·80	−21·80	...	5·7	Carinæ		7	2	4	−56	34	1
233·95	− 4·77	...	5·9 neb.	Velorum		8	38	23	−47	40	1
234·30	+ 2·74	...	5·9	*z* „		9	9	56	−42	43	9

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880 h	m	s	δ 1880 °	′	″
234·63	−14·64	...	6·1	Carinæ	7	49	38	−54	3	4
234·67	+ 6·83	...	3·7	ψ Velorum, ψ Argus	9	25	58	−39	56	5
234·87	− 2·84	...	5·8	,,	8	49	49	−47	3	9
235·01	+ 6·89	...	6·0	,,	9	27	33	−40	7	1
235·02	+ 1·15	...	5·6	,,	9	6	43	−44	22	6
235·08	− 6·31	...	5·6	C ,,	8	31	4	−49	31	9
235·19	− 9·05	...	5·7	,,	8	22	6	−51	20	1
235·24	− 2·02	...	5·9	,,	8	54	48	−46	46	2
235·28	+ 2·24	...	5·6	,,	9	11	57	−43	45	9
235·37	+21·84	5·5	5·8	Hydræ, Antliæ	10	12	38	−28	23	5
235·49	− 5·62	...	5·8	D Velorum	8	39	55	−49	23	4
235·58	− 7·31	...	6·4	,,	8	32	17	−50	33	2
235·76	− 1·27	...	4·6	*c* ,,	9	0	1	−46	37	2
236·11	+13·87	...	5·6	*η* Antliæ	9	53	43	−35	19	0
236·21	−22·77	...	6·0*d*	Carinæ	7	1	25	−59	0	0
236·22	−16·07	...	5·9	,,	7	46	32	−56	6	5
236·28	− 0·01	...	6·2	Velorum	9	7	19	−46	5	6
236·49	− 9·61	...	5·7	F ,,	8	24	19	−52	41	5
237·43	−15·82	...	6·1	Carinæ	7	52	24	−56	59	2
237·45	−13·47	...	6·0	,,	8	6	46	−55	43	9
237·48	+ 5·64	...	6·0	*y* Velorum	9	33	20	−42	39	0
237·55	− 8·01	...	4·0 cum.	*o* ,, , *o* Argus	8	36	51	−52	29	8
237·62	− 8·13	...	6·1	,,	8	36	32	−52	37	8
237·87	− 8·48	...	6·2	,,	8	36	1	−53	1	0
...	...	...	6·6	,,	8	38	53	−52	40	2
237·90	−78·89	...	6·3 } 5·7	,,	8	38	59	−52	41	1
238·35	+21·17	4·5	4·4	*α* Antliæ	10	31	40	−30	27	4
238·50	−25·36	...	3·5	*α* Pictoris	6	46	58	−61	48	8
238·99	− 6·05	...	5·4	H Velorum	8	52	42	−52	15	8
239·03	+13·63	var.	6·5−8	R Antliæ	10	4	35	−37	8	6
239·17	− 5·08	...	5·9	Velorum	8	58	1	−51	43	0
239·35	− 8·78	...	2·2	*δ* ,, , *δ* Argus	8	41	23	−54	16	2
239·66	+ 5·39	...	6·0	,,	9	41	50	−44	12	0
239·78	−17·92	...	6·2	Carinæ	7	47	14	−59	59	1
240·16	− 2·49	...	5·8	K Velorum	9	14	6	−50	32	8
240·33	−17·02	...	6·1	Carinæ	7	55	34	−59	58	9
240·66	+ 0·72	...	5·6	Velorum	9	29	26	−48	28	4
240·71	−16·95	...	5·5	Carinæ	7	57	34	−60	15	4

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.		α 1880. h	m	s	δ 1880. °	′	″
°	°	m	m								
240·75	+ 4·99	...	5·6	u Velorum		9	45	18	−45	10	4
240·87	−17·15	...	cum. 5^m h. 3111	Carinæ	6^m·7	7	56	50	−60	29	8
241·08	+ 5·80	...	6·1	Velorum		9	49	34	−44	43	0
241·14	− 9·76	...	5·1	f Carinæ		8	43	36	−56	19	7
241·14	−11·73	...	5·4	e_2 ,,		8	32	30	−57	35	7
241·22	+ 4·76	...	6·2	Velorum		9	46	41	−45	38	0
241·28	+ 0·78	...	4·9	M ,,		9	32	32	−48	49	1
241·31	−11·87	...	5·9	e_1 Carinæ		8	32	28	−57	48	6
241·36	−13·95	...	2·1	ϵ ,, , ϵ Argus		8	20	3	−59	7	4
241·48	+ 4·52	...	4·8 *d*	m Velorum		9	47	2	−45	59	1
241·53	+14·88	...	5·7	Antliæ		10	18	14	−37	24	1
241·86	− 1·57	...	5·9	Velorum		9	26	0	−50	59	5
241·96	−16·33	...	5·3	B Carinæ		8	7	1	−60	56	3
242·17	− 0·95	...	5·5	L Velorum		9	29	59	−50	43	3
242·30	+21·42	...	5·9	Antliæ		10	37	10	−32	5	3
242·34	+10·51	...	4·0	q Velorum		10	9	42	−41	31	7
242·66	− 3·34	...	5·8	I ,,		9	22	24	−52	51	6
242·89	− 6·13	...	6·0	,,		9	10	45	−55	4	4
242·97	−12·28	...	4·7	d Carinæ		8	37	58	−59	20	0
243·00	+ 9·75	...	6·2	Velorum		10	10	29	−42	30	8
243·30	+11·66	...	5·3	r ,,		10	17	11	−41	2	8
243·31	− 4·96	...	2·7	κ ,, , κ Argus		9	18	24	−54	29	9
243·47	−18·36	...	5·2	D Carinæ		7	58	49	−63	14	1
243·79	−16·58	...	5·7 *d*	C ,,		8	13	27	−62	32	7
243·93	−10·35	...	5·4 *d*	b_1 ,,		8	54	2	−58	46	0
243·98	+ 5·29	...	5·7	Velorum		10	1	26	−46	47	0
244·04	−10·02	...	5·7	b_2 Carinæ		8	56	28	−58	37	5
244·11	+ 1·87	...	6·1	Velorum		9	50	23	−49	40	6
244·15	− 2·48	...	6·0	,,		9	33	12	−53	7	7
244·38	+14·69	...	5·9	Antliæ		10	29	53	−38	56	5
244·41	+20·94	...	5·8	,,		10	44	22	−33	25	4
244·46	− 7·36	...	4·8	g Carinæ		9	12	49	−57	2	4
244·52	+ 1·05	...	6·2	Velorum		9	49	26	−50	34	8
244·85	−11·47	...	4·0	c Carinæ		8	52	20	−60	11	2
244·97	− 2·07	...	5·8	O Velorum		9	39	38	−53	20	5
244·98	− 8·86	...	3·8	a Carinæ		9	7	48	−58	28	6
245·23	−14·49	...	6·0	,,		8	35	11	−62	25	9
245·37	−20·59	...	6·2	Volantis		7	48	53	−65	53	4

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h	m	s	δ 1880. °	′	″
°	°	m	m							
245·48	− 9·00	...	6·1	Carinæ	9	9	47	− 58	55	2
245·62	− 5·61	var.	3·4 − 4·4	N Velorum	9	27	35	− 56	30	3
245·76	− 8·52	...	2·5	ι Carinæ, ι Argus	9	13	53	− 58	46	3
245·79	− 24·21	...	4·1	δ Volantis	7	16	53	− 67	44	2
246·36	− 17·76	...	5·7	,,	8	16	59	− 65	14	2
246·58	+ 9·58	...	5·4 *d*	*s* Velorum	10	26	49	− 44	27	2
246·68	+ 1·30	var.	6·5 − 7·5	R ,,	10	1	38	− 51	36	2
246·83	+ 1·85	...	5·3	Q ,,	10	4	23	− 51	13	4
246·91	− 1·44	...	3·9	φ ,, , φ Argus	9	52	39	− 53	59	8
247·09	+ 2·71	...	5·8	,,	10	8	45	− 50	38	3
247·14	+ 18·77	...	5·1	ι Antliæ	10	51	8	− 36	29	6
247·21	− 5·52	...	6·0	Carinæ	9	37	1	− 57	26	3
247·25	− 17·41	...	3·9	β Volantis	8	24	26	− 65	44	2
247·39	− 7·00	...	4·9	*h* Carinæ	9	30	58	− 58	41	7
247·39	+ 2·28	...	6·2	Velorum	10	8	52	− 51	9	7
247·44	− 11·18	...	4·3	*i* Carinæ	9	8	33	− 61	49	5
247·69	+ 7·98	...	5·6	*t* Velorum	10	27	53	− 46	23	1
248·14	− 10·61	...	5·5	*k* Carinæ	9	18	4	− 61	53	6
248·16	+ 20·66	...	5·8	Antliæ	10	59	14	− 35	9	5
248·53	− 20·18	...	4·5	ε Volantis	8	7	32	− 68	15	9
248·93	+ 7·25	...	4·1	*p* Velorum	10	32	16	− 47	36	2
249·23	− 8·21	...	5·1	*m* Carinæ	9	36	2	− 60	47	1
249·35	− 15·82	...	5·9	Volantis	8	48	57	− 66	20	7
249·36	− 12·89	...	neb. h. 3152	Carinæ	9	9	41	− 64	22	1
249·55	− 9·86	var.	4·3 − 10	R ,,	9	29	14	− 62	15	5
249·82	− 14·66	...	4·2	α Volantis	9	0	33	− 65	55	0
249·89	− 0·02	...	5·4	Velorum	10	15	6	− 54	25	6
249·96	+ 14·40	...	4·5	*i* ,, , Centauri	10	54	39	− 41	35	0
250·52	− 8·68	var.	3·7 − 5·2	*l* Carinæ	9	41	57	− 61	57	3
250·56	− 11·85	...	6·6	,,	9	24	8	− 64	24	6
250·58	− 0·79	...	5·0	J Velorum	10	16	27	− 55	26	4
250·59	+ 12·94	...	6·2	,, , Centauri	10	54	32	− 43	9	8
250·71	+ 0·64	...	6·2	,,	10	22	12	− 54	16	0
250·73	+ 1·98	...	5·6 *d*	,,	10	26	42	− 53	6	4
250·81	− 19·49	...	6·0	Volantis	8	26	59	− 69	41	7
250·84	− 5·54	...	6·8	Carinæ	9	59	8	− 59	35	9
250·87	− 5·81	...	6·4	,,	9	58	11	− 59	50	5
250·86	+ 6·90	...	2·9	μ Velorum, μ Argus	10	41	37	− 48	47	2

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h	m	s	δ 1880. °	′
		m	m						
251·19	− 8·46	...	6·2	Carinæ	9	47	33	−62	11·0
251·36	−23·87	...	4·3	ζ Volantis	7	43	17	−72	19·1
251·38	+ 14·53	...	5·5 *d*	Centauri	11	1	44	−41	59·5
251·66	−18·84	...	5·6	θ Volantis	8	38	38	−69	57·5
251·74	−20·77	...	5·2	κ₁ „	8	20	9	−71	8·0
...	...	...	5·7 } 4·7	κ₂ „	8	20	20	−71	7·4
252·01	+ 21·67	...	5·4 tr.	Centauri, Hydræ 5^{m}·7	11	17	24	−35	30·4
252·15	− 1·72	...	5·4	Carinæ, P Velorum	10	22	56	−57	1·6
252·26	− 6·24	var.	6·2−9	S „	10	5	33	−60	57·7
252·31	−10·56	...	3·3 *d*	υ „ , υ Argus	9	44	6	−64	30·9
252·56	−15·19	...	6·0	„	9	15	36	−68	11·0
252·62	+ 0·85	...	4·8 *d*	x Velorum	10	34	32	−54	58·7
252·74	− 2·64	...	4·6	s Carinæ	10	23	29	−58	7·6
252·87	+ 9·68	...	6·0	Velorum	10	59	7	−47	2·0
252·92	− 5·56	...	3·3	q Carinæ	10	13	5	−60	44·0
252·97	+ 9·98	...	6·9	Centauri	11	0	20	−46	47·7
253·07	− 1·12	...	5·3	r Carinæ	10	30	59	−56	56·2
253·07	−16·17	...	2·0	β „ , β Argus	9	11	52	−69	13·4
253·24	−17·20	...	5·2	E „	9	4	39	−70	3·3
253·38	− 1·67	...	5·7 cum.	„	10	31	8	−57	34·3
253·56	−21·60	...	5·7	η Volantis	8	23	8	−73	0·7
254·08	+ 0·29	...	5·8	Velorum	10	42	7	−56	7·5
254·10	− 2·84	...	5·5	t_1 Carinæ	10	31	51	−58	56·5
254·19	− 2·37	...	5·2 *d*	t_2 „	10	34	11	−58	33·5
254·60	− 9·82	...	5·7	„	10	5	22	−65	13·7
254·64	− 4·96	...	3·6	p „	10	27	46	−61	4·1
254·65	− 2·16	...	6·5	„	10	38	3	−58	35·2
254·65	+ 8·84	...	5·8	Centauri	11	7	5	−48	27·0
254·71	− 2·66	...	7·0 var.	Carinæ	10	36	43	−59	3·0
254·85	−18·59	...	4·8	G „	9	4	49	−72	7·2
254·97	+ 0·18	...	6·0	„	10	47	36	−56	36·2
255·13	− 2·45	var.	>1−7·2	η „ , η Argus	10	40	25	−59	3·2
255·21	+ 15·82	...	5·4 *d*	Centauri	11	22	48	−42	0·8
255·29	−16·68	...	6·0	Carinæ	9	25	55	−71	4·8
255·32	−10·02	...	5·7	M „	10	10	7	−65	46·7
255·32	+ 18·19	...	6·2	Centauri	11	26	58	−39	46·5
255·36	− 3·33	...	5·2	w Carinæ	10	38	58	−59	56·3
255·52	+ 18·09	...	5·7	Centauri	11	27	47	−39	55·5

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h m s	δ ° ′
255·55	− 7·30	...	6·1	Carinæ	10 24 53	−63 33·5
...	...	...	7·0	,,	10 43 3	−59 14·5
255·58	− 2·49	...	6·7	,,	10 43 24	−59 17·1
255·75	− 1·24	...	4·1	*u* ,,	10 48 37	−58 13·0
256·41	− 9·97	...	5·4	L ,,	10 19 25	−66 17·7
256·57	− 2·70	var.	6·2−6·8	,,	10 50 30	−59 52·8
256·61	− 1·82	var.	6·8−?	,,	10 52 55	−59 5·4
256·63	−17·51	...	5·9	H ,,	9 30 42	−72 32·9
256·74	−23·57	...	4·2	*a* Chamæleontis	8 21 36	−76 32·4
256·93	− 6·34	...	5·6	Carinæ	10 39 47	−63 19·9
256·97	− 6·88	...	5·7	,,	10 37 59	−63 50·3
257·01	− 6·78	...	2·9	*θ* ,, , *θ* Argus	10 38 41	−63 46·0
257·24	− 0·42	...	6·5 cum.	,,	11 1 24	−58 1·6
257·26	−19·49	...	5·7	,,	9 17 37	−74 23·3
257·30	− 6·49	...	6·2	,,	10 42 7	−63 37·9
257·34	−23·73	...	4·7	*θ* Chamæleontis	8 24 13	−77 5·8
257·38	− 6·59	...	5·8 cum.	Carinæ	10 42 29	−63 45·1
257·39	−13·07	...	3·6	*ω* ,, , *ω* Argus	10 10 53	−69 26·5
257·60	− 0·60	...	4·6	*x* ,,	11 3 28	−58 19·5
257·67	+16·06	...	6·1	Centauri	11 35 26	−42 25·8
257·69	+ 4·18	...	4·3	*π* ,,	11 15 32	−53 50·0
257·75	+11·65	...	6·0	C_1 ,,	11 29 26	−46 42·5
257·94	+11·43	...	5·5	C_2 ,,	11 30 7	−46 58·4
258·04	+18·81	...	5·4	,,	11 40 48	−39 50·8
258·19	+ 9·94	...	6·0	,,	11 29 12	−48 28·7
258·24	+11·40	...	5·9	C_3 ,,	11 31 45	−47 5·0
258·55	− 1·68	...	5·2	*y* Carinæ	11 7 27	−59 39·9
258·62	− 3·90	...	5·3	*z* ,,	11 1 38	−61 46·6
258·67	− 3·36	...	6·0	,,	11 3 35	−61 17·9
259·11	+13·74	...	5·9	Centauri	11 39 48	−45 1·4
259·32	−23·60	...	5·6	*η* Chamæleontis	8 45 22	−78 31·6
259·55	+ 4·99	...	5·2	A Centauri	11 29 5	−53 36·1
259·62	−14·02	...	5·0	K Carinæ	10 27 18	−71 22·5
259·90	− 5·29	...	5·7	,,	11 7 48	−63 31·0
259·95	+14·45	...	5·0	B Centauri	11 45 9	−44 30·3
259·99	−19·62	...	6·1	*ν* Chamæleontis	9 45 16	−76 13·0
260·31	−15·06	...	5·6	Carinæ	10 28 14	−72 36·3
260·32	−15·99	...	4·4	I ,,	10 22 1	−73 25·3

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
260·43	− 1·89	...	6·2		Centauri	11	21	12	−60	27	3
260·56	− 0·10	...	5·2		o_1 ,,	11	26	14	−58	46	8
260·59	− 0·17	...	5·5		o_2 ,,	11	26	16	−58	51	2
261·19	− 4·64	...	5·7		,,	11	20	32	−63	18	6
261·24	− 5·66	...	5·7	*d*	Muscæ, Carinæ	11	18	11	−64	17	8
261·55	− 1·50	...	6·6	cum.	Centauri	11	30	47	−60	23	3
261·61	− 2·03	...	6·5	cum.	,, 7m	11	30	11	−60	54	9
261·69	− 1·70	...	5·9		,,	11	31	28	−60	37	2
261·70	+ 17·57	...	5·7		,,	11	57	27	−41	45	7
261·80	− 11·75	...	6·1		Carinæ	11	2	30	−70	13	8
261·95	− 2·19	...	6·0		Centauri	11	32	31	−61	9	8
261·99	− 3·41	...	3·4		λ ,,	11	30	15	−62	21	4
262·14	− 23·25	...	5·8		ι Chamæleontis	9	28	6	−80	16	1
262·33	− 2·37	...	5·7		Centauri	11	35	14	−61	25	5
262·50	+ 19·36	...	5·9		,,	12	2	42	−40	33	8
262·55	− 23·08	...	5·5		ζ Chamæleontis	9	37	22	−80	24	1
262·59	+ 2·92	...	6·1		Centauri	11	46	15	−56	19	3
262·72	− 2·68	...	5·8		,,	11	37	48	−61	49	4
262·77	− 1·32	...	4·7		,,	11	40	43	−60	30	7
263·00	− 5·61	...	5·8		Muscæ, Centauri	11	33	56	−64	44	0
263·00	+ 15·85	...	6·2		Centauri	12	2	42	−43	39	4
263·28	+ 3·74	...	6·1		Crucis, Centauri	11	52	12	−55	39	0
263·37	− 19·59	...	4·4		γ Chamæleontis	10	34	2	−77	59	1
263·55	+ 11·51	...	6·1		E Centauri	12	2	2	−48	1	5
263·60	− 12·58	...	6·1		Muscæ, Chamæleontis	11	19	25	−71	35	9
263·69	− 3·79	...	4·9		*j* Centauri	11	43	51	−63	7	3
263·80	+ 9·56	...	5·8		,,	12	1	53	−49	59	6
263·85	+ 9·51	...	2·8		δ ,,	12	2	9	−50	3	2
263·93	− 6·76	...	3·8		λ Muscæ	11	39	57	−66	3	8
264·13	+ 14·59	...	5·8	*d*	D Centauri	12	7	47	−45	3	4
264·19	− 6·78	...	5·3		μ Muscæ	11	42	29	−66	8	8
264·22	− 5·13	...	5·5	*d*	,, , Centauri	11	46	0	−64	32	3
264·27	− 23·38	...	6·0		μ Chamæleontis	10	3	52	−81	38	0
264·60	+ 7·95	...	4·5		ρ Centauri	12	5	23	−51	42	0
...	...	...	6·2	4·5	δ_1 Chamæleontis	10	44	6	−79	50	2
264·80	− 21·06	...	4·9		δ_2 ,,	10	44	38	−79	54	5
265·07	− 3·05	...	4·7		θ_1 Crucis	11	56	55	−62	38	7
265·10	− 10·08	...	5·6		Muscæ	11	44	13	−69	33	5

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h	m	s	δ 1880. °	′
265·18	− 2·88	...	5·3	θ_2 Crucis	11	58	9	−62	29·9
265·58	−15·80	...	6·2	π Chamæleontis	11	32	20	−75	14·0
265·68	− 4·27	...	4·7	η Crucis	12	0	38	−63	56·7
265·88	+ 1·68	...	3·4	δ „	12	8	47	−58	4·9
266·01	+ 5·32	...	5·8	F Centauri	12	12	36	−54	28·6
266·03	− 7·97	...	6·0	Muscæ	11	58	28	−67	39·6
266·81	+ 9·10	...	5·7	G Centauri	12	20	3	−50	47·1
266·84	+ 0·12	...	4·0	ϵ Crucis	12	14	54	−59	44·3
266·85	− 3·51	...	4·6	ζ „	12	11	57	−63	20·2
266·96	+10·33	...	4·3	σ Centauri	12	21	33	−49	33·9
267·02	− 9·67	var.	6·5 − ?	Muscæ	12	6	20	−69	29·0
267·19	− 7·45	...	4·7 var.?	ϵ „	12	11	6	−67	17·6
267·22	− 1·08	...	... var.?	Crucis	12	17	3	−60	57·8
267·38	−16·06	...	5 6	κ Chamæleontis	11	58	36	−75	51·2
267·39	−14·89	...	5·8	Muscæ, Chamæleontis	12	1	32	−74	42·0
267·40	−17·78	...	5·0	ϵ Chamæleontis	11	53	41	−77	33·2
267·47	+ 4·18	...	6·2	Crucis, Centauri	12	22	2	−55	44·2
267·58	− 6·97	...	5·8	ζ Muscæ	12	15	28	−66	51·4
267·65	+ 4·05	...	5·9	Crucis, Centauri	12	23	18	−55	51·7
267·68	− 2·42	...	1·3 *d*	α „	12	19	56	−62	26·0
267·80	+15·95	...	6·2	Centauri	12	28	13	−44	0·2
267·84	+19·60	...	5·7	„	12	29	18	−40	21·6
267·86	+ 3·50	...	2·0	γ Crucis	12	24	31	−56	26·5
268·48	+12·10	...	4·4	τ Centauri	12	31	9	−47	52·8
268·51	−18·73	...	4·6	β Chamæleontis	12	11	20	−78	38·8
268·63	+20·66	...	5·2	l Centauri	12	33	23	−39	19·6
268·81	−11·50	...	4·0	γ Muscæ	12	25	19	−71	28·2
268·83	−12·37	...	6·2	„	12	24	56	−72	20·2
269·08	− 8·48	...	2·9	α „	12	30	3	−68	28·4
269·13	+11·69	...	2·4	γ Centauri	12	34	54	−48	18·0
269·31	+11·84	...	5·4	w „	12	35	57	−48	9·2
269·36	+ 0·97	...	6·0	Crucis	12	35	3	−59	1·6
269·46	− 2·32	...	cum. h. 3407	„	12	35	23	−62	18·7
269·51	− 2·40	...	6·1	„	12	35	49	−62	24·0
269·52	− 8·75	var.	6·6 − 7·4	R Muscæ	12	34	46	−68	44·9
269·70	− 7·45	...	3·4	β „	12	38	56	−67	27·1
269·82	− 0·32	...	5·7	ι Crucis	12	38	35	−60	19·3
269·93	+ 4·17	...	5·4	„ , Centauri	12	39	30	−55	49·9

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
°	°	m	m								
270·10	+ 0·97	...	1·7		β Crucis	12	40	43	−59	1	9
270·64	+ 7 86	...	6·2		Centauri	12	44	6	−52	8	0
270·70	+ 2·22	var.	6·8−7·6		Crucis	12	47	17	−57	46	7
270·79	+ 0·32	...	6·3	cum. 5·6	,,	12	46	13	−59	40	5
270·84	+ 0·27	...	6·7		κ ,,	12	46	40	−59	43	4
270·99	+ 1·49	...	5·6		λ ,,	12	47	32	−58	29	7
271·00	− 10·21	...	cum. h. 3444		Muscæ	8m 12	51	38	−70	11	1
271·04	+ 3·46	...	4·4	4·1	μ Crucis	12	47	33	−56	31	6
...	...	...	5·5		,,	12	47	34	−56	31	0
271·08	+ 11·70	...	5·0		e Centauri	12	46	20	−48	17	4
271·17	− 10·93	...	3·7		δ Muscæ	12	54	2	−70	54	1
271·24	+ 3·79	...	6·0		Crucis, Centauri	12	48	54	−56	11	1
271·44	+ 20·46	...	4·4		n Centauri	12	46	48	−39	31	5
271·64	+ 9·42	...	5·8		H ,,	12	50	10	−50	32	9
271·68	+ 17·71	...	6·1		,,	12	48	38	−42	15	8
272·19	− 4·75	...	5·9		θ Muscæ	13	0	23	−64	39	8
272·49	− 14·43	...	5·6		ι_1 ,,	13	15	42	−74	15	4
272·64	− 7·39	...	5·3		η ,,	13	7	8	−67	15	5
272·78	+ 11·03	...	5·8		ξ_1 Centauri	12	56	37	−48	52	9
272·80	− 23·59	...	4·7		δ Octantis	14	7	52	−83	6	9
272·96	− 6·31	...	5·5		Muscæ	13	9	9	−66	8	9
273·12	+ 7·06	...	6·1		Centauri	13	0	31	−52	49	0
273·16	+ 0·57	...	5·4		,,	13	4	49	−59	16	9
273·21	− 10·23	...	6·1		Muscæ	13	17	7	−70	0	0
273·30	+ 10·61	...	4·8		ξ_2 Centauri	12	59	55	−49	15	8
273·31	+ 12·05	...	5·3		*f* ,,	12	59	20	−47	49	2
273·50	+ 1·36	...	5·9		,,	13	6	50	−58	27	7
273·62	− 21·02	...	5·3		η Apodis	14	3	16	−80	26	6
273·65	+ 7·57	var.	6·7−7·2		Centauri	13	3	40	−52	16	1
273·95	− 4·18	...	5·2		*m* ,, , Muscæ	13	15	58	−63	54	4
273·95	+ 18·91	...	6·3		,,	12	59	48	−40	56	7
273·98	− 23·67	...	6·0		π_1 Octantis	14	40	54	−82	44	4
274·15	− 20·25	...	5·5		ε Apodis	14	7	58	−79	33	2
274·18	− 23·55	...	5·9		π_2 Octantis	14	44	4	−82	33	2
274·30	− 0·64	...	5·2		J Centauri	13	14	53	−60	21	5
274·51	− 16·85	...	5 var.		θ Apodis	13	53	41	−76	13	0
274·71	+ 17·05	...	5·7		Centauri	13	4	32	−42	43	7
274·78	+ 18·19	...	6·1		,,	13	4	19	−41	35	6

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
°	°	m	m								
275·15	+ 7·56	...	6·1		Centauri	13	13	21	−52	7	0
275·73	+ 16·33	...	6·1		„	13	10	17	−43	20	7
275·74	− 19·77	...	4·0		α Apodis	14	33	2	−78	32	0
276·72	− 3·05	...	cum. h. 3531		Centauri	7m·0 13	38	14	−62	18	4
276·74	+ 8·92	...	5·8	K	„	13	22	4	−50	32	6
276·95	+ 12·63	...	cum. 4m	ω	„	13	19	46	−46	51	6
277·08	+ 1·10	...	6·1		„	13	34	4	−58	10	7
277·21	− 10·26	...	6·4		Circini, Apodis	14	1	10	−69	8	9
277·45	− 17·95	...	5·5		Apodis	14	44	16	−76	10	3
277·45	+ 23·44	...	3·0	ι	Centauri	13	13	51	−36	4	7
277·73	− 4·11	...	5·7		„	13	48	59	−63	5	8
277·90	+ 6·36	...	2·6	ε	„	13	32	18	−52	51	3
277·94	+ 5·24	...	5·7 *d*	Q	„	13	34	4	−53	57	0
277·95	+ 18·53	...	6·2		„	13	19	57	−40	52	4
278·09	+ 20·27	...	5·9		„	13	19	10	−39	7	7
278·75	− 7·48	...	6·2		Circini	14	7	11	−66	1	6
278·93	− 14·77	...	6·1		Apodis	14	41	16	−72	41	6
278·94	− 9·27	...	6·0		Circini, Apodis	14	15	11	−67	38	9
279·15	+ 20·45	...	4·5	*d*	Centauri	13	24	5	−38	47	2
279·35	− 1·13	...	1·2	β	„	13	55	22	−59	47	6
279·36	+ 8·13	...	5·2	M	„	13	39	4	−50	49	8
279·68	− 22·28	...	5·2 } 4·6	δ_1	Apodis	16	2	28	−78	23	4
...	...	...	5·5 }	δ_2	„	16	2	35	−78	21	7
279·78	+ 9·17	...	6·0		Centauri	13	40	8	−49	43	2
279·84	+ 6·58	...	5·9	N	„	13	44	21	−52	12	9
279·95	− 22·91	...	3·9	γ	Apodis	16	15	6	−78	37	5
280·47	+ 7·09	...	6·1		Centauri	13	47	28	−51	34	2
280·77	+ 19·48	...	6·2		„	13	32	46	−39	26	4
280·92	− 2·61	...	5·9		„	14	11	4	−60	42	9
281·00	− 1·19	var.	6·0−10	R	„	14	7	56	−59	21	2
281·23	− 16·42	...	5·8	κ_1	Apodis	15	18	28	−72	58	2
281·30	+ 12·32	...	6·2		Centauri	13	44	22	−46	18	2
281·48	− 22·47	...	4·5	β	Apodis	16	25	59	−77	15	7
281·71	− 8·74	...	6·1		Circini	14	38	36	−66	5	3
281·71	− 16·85	...	6	κ_2	Apodis	15	27	5	−73	2	9
281·75	+ 1·54	...	5·6		Centauri	14	6	36	−56	31	4
281·83	+ 11·77	...	2·7	ζ	„	13	48	4	−46	41	8
281·85	− 7·01	...	3·5	α	Circini	14	32	50	−64	27	0

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h	m	s	δ 1880. °	′
282·03	−12·94	...	6·2	Triang. aust.	15	2	50	−69	37·5
282·07	+16·70	...	3·4	μ Centauri	13	42	24	−41	52·5
282·24	− 0·10	...	5·6 *d*	„	14	14	2	−57	54·6
282·25	+17·46	...	3·7	ν „	13	42	19	−41	5·3
282·25	+ 5·23	...	5·4	„	14	1	56	−52	52·0
282·41	−11·57	var.	7·0	T Triang. aust.	14	58	36	−68	15·4
282·64	+ 4·85	...	6·1	Centauri	14	5	12	−53	6·0
282·67	+ 1·95	...	5·0	ν „	14	11	57	−55	50·0
283·03	− 5·24	...	6·0	Circini, Centauri	14	35	48	−62	21·7
283·06	+14·02	...	4·2	υ_1 Centauri	13	51	16	−44	13·0
283·17	−11·99	...	3·1	γ Triang. aust.	15	7	44	−68	14·1
283·36	+13·10	...	5·0	υ_2 Centauri	13	54	15	−45	1·3
283·40	− 3·18	...	0·7 *d*	α „	14	31	27	−60	20·4
283·44	+10·22	...	cum. h. 3555	„	8m·7	13	59	34	−47	44·9
283·78	+16·64	...	4·1	φ „	13	50	59	−41	30·8
283·90	−17·32	...	6·1	Apodis	15	52	35	−72	4·0
284·24	− 5·76	...	5·8	θ Circini	14	47	5	−62	17·5
284·42	− 7·29	...	5·9	η „	14	54	47	−63	33·5
284·46	−10·21	var.	6·6−8·0	R Triang. aust.	15	9	3	−66	3·2
285·39	− 3·34	...	5·9	Circini	14	46	20	−59	37·2
285·52	+17·07	...	4·8	χ Centauri	13	58	43	−40	36·2
285·87	− 7·67	...	5·5	ε Circini	15	7	32	−63	9·9
285·93	−13·95	...	5·7	κ Triang. aust.	15	43	40	−68	14·6
285·97	−11·04	...	4·6	ε „ „	15	25	45	−65	54·7
286·18	+ 1·31	...	6·5	Circini, Centauri	14	36	33	−55	5·5
286·19	+11·68	...	3·8	ι Lupi	14	11	44	−45	30·2
286·58	−18·01	...	5·9	Apodis, Triang. aust.	16	21	6	−70	43·5
286·60	+ 6·77	...	5·2	σ Lupi	14	24	32	−49	55·4
286·63	+ 7·78	...	5·9	„	14	22	22	−48	58·9
286·73	+12·41	...	5·7	„ , Centauri	14	13	3	−44	37·9
286·96	−17·05	...	5·6	ζ Triang aust.	16	15	34	−69	48·7
...	...	...	6·3	Circini	15	6	56	−60	27·4
287·23	− 5·40	...	5·6 } 5·4	δ „	15	7	16	−60	30·6
287·28	+21·61	...	2·2	5 θ Centauri	13	59	37	−35	46·7
287·44	−11·06	...	6·1	Triang. aust.	15	36	58	−65	3·8
287·57	+11·87	...	4·9	τ_2 Lupi	14	18	28	−44	50·1
287·62	+12·02	...	5·3	τ_1 „	14	18	26	−44	40·6
287·68	− 5·12	...	5·9	Circini	15	9	10	−60	3·2

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
287·80	+ 7·37	...	4·5	ρ	Lupi	14	29	49	−48	54	1
287·83	+ 4·09	...	5·8	b	„	14	38	38	−51	52	5
288·04	− 5·55	...	6·1		Circini	15	13	28	−60	13	4
288·25	+ 11·66	...	6·2		Lupi	14	22	25	−44	47	0
288·46	− 3·61	...	4·7	β	Circini	15	8	8	−58	21	1
288·61	− 11·50	...	6·1		Triang. aust.	15	47	59	−64	41	2
288·81	− 4·45	...	5·2	γ	Circini	15	13	50	−58	53	2
288·88	+ 10·38	...	6·2		Lupi	14	28	28	−45	43	2
288·89	+ 3·07	...	6·0	c	„	14	47	45	−52	19	3
288·99	− 17·75	...	2·2	α	Triang. aust.	16	35	58	−68	48	3
289·09	+ 10·41	...	6 0 *d*		Lupi	14	29	29	−45	36	5
289·27	+ 8·94	...	2 6	α	„	14	33	57	−46	52	3
289·30	+ 17·53	...	4·9	α	Centauri	14	15	39	−38	57	7
289·38	− 10·01	...	3·1	β	Triang. aust.	15	44	35	−63	3	5
289·38	− 18·68	...	6·2		„ „	16	46	42	−69	4	5
289·47	+ 19·22	...	4·4	ψ	Centauri	14	13	16	−37	19	9
289·55	− 0·22	...	6·3		Lupi	15	2	20	−54	53	2
289·71	− 20·79	...	5·8	ι	Apodis	17	8	44	−69	59	6
290·46	− 16·44	...	5 6		Triang. aust.	16	34	36	−66	52	9
290·47	+ 14·17	...	2·5	η	Centauri	14	27	53	−41	37	8
290·88	− 11·74	...	4·3	δ	Triang. aust.	16	4	32	−63	22	6
291·04	− 14·56	...	6·0	θ	„ „	16	24	12	−65	14	3
291·27	+ 7·39	...	6·1 *d*		Lupi	14	48	23	−47	23	5
291·37	+ 2·47	...	3·6	ζ	„	15	3	40	−51	38	5
291·39	− 7·85	...	6·2		Triang. aust.	15	46	0	−60	7	4
291·53	+ 15·84	...	6·2		Centauri	14	29	12	−39	41	1
291·54	− 7·58	...	6·2		Normæ, Triang. aust.	15	45	30	−59	49	0
291·58	− 12·99	...	5·8	ι	Triang. aust.	16	16	49	−63	47	0
291·88	− 19·61	...	5·4	ζ	Apodis	17	9	27	−67	38	5
292·09	− 8·48	...	cum. h. 3616		Triang. aust. 6m·8	15	53	33	−60	9	6
292·55	+ 11·59	...	5·0	o	Lupi	14	43	49	−43	4	6
292·95	+ 7·41	...	4·3	π	„	14	56	57	−46	34	8
293·07	+ 5·37	...	4·1 *d*	κ	„	15	3	36	−48	16	8
293·57	+ 17·58	...	4·2	b	Centauri	14	34	31	−37	16	6
293·64	− 11·60	...	5·8		Triang. aust., Aræ	16	20	10	−61	21	9
293·89	+ 11·39	...	2·8	β	Lupi	14	50	41	−42	38	9
293·91	− 6·46	...	5·4	ι_1	Normæ	15	53	47	−57	26	1
294·17	+ 19·15	...	6·2		Centauri	14	33	39	−35	37	0

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
		m	m								
294·37	− 3·26	...	6·1		Normæ	15	41	48	−54	41	1·3
294·37	− 7·07	...	6·0		„	15	59	27	−57	36	6·6
294·42	+ 8·60	...	4·8	λ	Lupi	15	0	46	−44	49	0·0
294·47	+ 5·52	...	4·8 *d*	μ	„	15	10	11	−47	25	9·9
294·51	+12·23	...	3·3	κ	Centauri	14	51	22	−41	37	3·3
294·57	− 0·02	...	5·8		Normæ	15	29	55	−51	58	5·5
294·96	+ 5·15	...	5·8	ν_1	Lupi	15	13	47	−47	29	4·4
295·02	− 7·66	...	6·0		Normæ	16	5	55	−57	36	3·3
295·14	+19·77	...	4·3	c_1	Centauri	14	36	19	−34	39	3·3
295·32	− 7·93	...	cum. h. 3622	R	Normæ	16	8	56	−57	36	1·1
295·37	+18·01	...	6·8		Centauri	14	41	12	−36	7	8·8
295·42	+19·61	...	5·4	c_2	„	14	37	38	−34	40	0·9
295·42	− 1·74	...	6·0		Normæ	15	41	1	−52	50	3·3
295·44	+ 8·90	...	5·5	*e*	Lupi	15	4	46	−44	2	7·7
295·56	+16·58	...	5·7		Centauri, Lupi	14	45	20	−37	18	5·5
295·68	− 9·30	...	6·1		Normæ, Aræ	16	18	8	−58	19	5·5
295·78	− 3·82	...	6·7		„	15	51	46	−54	14	0·0
295·93	−20·28	...	3·8	η	Pavonis	17	33	58	−64	39	8·8
296·06	+12·55	...	5·7		Lupi	14	57	32	−40	35	9·9
296·44	−17·28	...	6·2		Aræ	17	12	45	−62	44	6·6
296·54	+ 5·44	...	5·9		Lupi	15	21	3	−46	18	9·9
296·79	+12·69	...	6·2		„	15	0	26	−40	7	1·1
296·82	+ 7·78	...	3·7	ε	„	15	14	32	−44	15	4·4
297·07	− 5·06	...	5·5	κ	Normæ	16	4	1	−54	19	1·1
297·20	−11·69	...	3·8	η	Aræ	16	39	26	−58	49	5·5
297·34	− 4·74	...	cum. 6·0 h. 3619		Normæ	16	3	53	−53	54	
297·34	−11·01	...	6·1		Aræ	16	36	7	−58	16	7·7
297·55	−11·01	...	6·0		„	16	37	7	−58	7	1·1
297·58	+11·13	...	5·8		Lupi	15	8	11	−41	2	7·7
297·93	− 9·36	...	var. 7−8		Aræ	16	29	47	−56	45	1·1
297·98	− 4·80	...	6·0		Normæ	16	7	20	−53	30	5·5
298·06	−22·12	...	4·6	π	Pavonis	17	57	2	−63	40	2·2
298·13	+19·74	...	5·8		Centauri	14	48	23	−33	22	0·0
298·44	+11·42	...	6·2		Lupi	15	11	5	−40	20	8·8
298·59	+ 6·22	...	5·1 *d*	*d*	„	15	27	38	−44	33	3·3
298·86	−16·89	...	3·7	δ	Aræ	17	20	16	−60	34	9·9
298·91	+11·28	...	3·7	δ	Lupi	15	13	30	−40	12	7·7
298 98	−22·64	...	6·0		Pavonis	18	4	17	−63	5	0·0

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h	m	s	δ 1880. °	′	″
		m	m							
298°99	+ 6°65	...	6·2	Lupi	15	27	59	−43	59	6
299·48	−12·40	...	6·2	Aræ	16	54	12	−57	32	2
299·55	+ 5·90	...	5·2	*g* Lupi	15	32	57	−44	15	7
299·55	− 0·01	...	5·2	*η* Normæ	15	54	24	−48	53	6
299·80	−21·70	...	5·8	*ι* Pavonis	17	59	17	−62	1	5
299·99	+11·69	...	5·9	*υ* Lupi	15	16	55	−39	16	9
300·17	+20·01	...	5·8	„	14	55	39	−32	10	1
300·36	+ 7·90	...	4·7	*ω* „	15	29	58	−42	10	3
300·40	+10·74	...	3·2	*ζ* Aræ	16	48	42	−55	47	9
300·59	−18·87	...	6·2	Pavonis, Telescopii	17	40	48	−60	7	4
300·62	− 2·15	...	5·4	γ_1 Normæ	16	8	2	−49	46	0
300·66	+12·43	...	5·1	*k* Lupi	15	17	34	−38	18	4
300·76	+ 9·35	...	3·2	*γ* „	15	27	9	−40	45	7
300·90	− 2·52	...	4·6	γ_2 Normæ	16	10	52	−49	51	5
300·90	−22·93	...	4·4	*ξ* Pavonis	18	12	10	−61	32	7
301·40	+14·22	...	5·1	ϕ_2 Lupi	15	15	29	−36	25	6
301·52	+14·86	...	3·6	ϕ_1 „	15	14	12	−35	49	5
301·60	− 2·40	...	5·9	Normæ	16	13	30	−49	17	0
302·15	+13 81	...	6·0	Lupi	15	19	37	−36	20	7
302·26	−14·01	...	3·6	*γ* Aræ	17	15	18	−56	15	7
302·28	0·00	...	5·4	*θ* Normæ	16	6	33	−47	3	9
302·56	+10·58	...	6·1	Lupi	15	30	49	−38	43	9
302·66	+ 2·64	...	4·9	*δ* Normæ	15	58	1	−44	50	8
302·75	− 9·12	...	4·2	ϵ_1 Aræ	16	50	1	−52	58	4
302·99	−13·54	...	2·8	*β* „	17	15	20	−55	24	8
303·02	+19·62	...	5·5	1 *i* Lupi	15	7	16	−31	4	2
303·03	− 9·58	...	5·9	ϵ_2 Aræ	16	53	34	−53	3	3
303·59	− 1·55	...	4·8 *d*	*ε* Normæ	16	18	23	−47	16	7
303·67	− 4·73	...	6·0	Aræ	16	32	35	−49	24	9
303·99	+ 6·05	...	5·5	Lupi	15	21	20	−41	23	9
304·17	− 0·94	...	5·9	Normæ	16	21	1	−45	58	5
304·25	+11·45	...	5·8	*h* Lupi	15	34	50	−37	2	3
304·33	− 4·09	...	5·6 *d*	Aræ	16	32	21	−48	31	5
304·39	− 7·16	...	6·9	„	16	46	54	−50	28	7
304·45	+20·36	4·7	4·7	2 *f* Lupi	15	10	32	−29	42	4
304·63	− 7·40	...	6·0	Aræ	16	49	2	−50	27	0
304·89	−14·56	...	5·8	*π* „	17	28	14	−54	25	1
305·25	−22·37	...	6·0	Pavonis	18	19	26	−57	35	7

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h	m	s	δ 1880. °	′	″
305·69	+14·18	4·6	5·1	3	ψ_1 Lupi		15	32	9	−34	1	1·1
305·82	−14·47	...	cum. neb. h. 3692		Aræ	6m·7	17	30	55	−53	36	6·6
305·99	+13·57	...	5·1	4	ψ_2 Lupi		15	35	2	−34	19	4·4
306·06	+ 2·89	...	5·7		λ Normæ		16	10	57	−42	22	7·7
306·07	−20·21	...	5·7		Telescopii		18	7	1	−56	3	5·5
306·31	+ 8·49	...	3·7		η Lupi		15	52	10	−38	3	1·1
306·61	−15·71	...	6·1 *d*		Aræ		17	40	42	−53	34	2·2
306·65	+ 7·91	...	5·6		Lupi		15	55	26	−38	16	0·0
306·67	+13·07	...	5·8		,,		15	39	5	−34	18	3·3
306·96	0·00	...	5·5		μ Normæ		16	25	34	−43	47	3·3
307·24	−10·95	...	5·8		κ Aræ		17	16	39	−50	31	3·3
307·73	−14·00	...	5·7		μ ,,		17	34	37	−51	46	1·1
308·05	+13·32	4·0	4·2	5	χ Lupi		15	43	20	−33	15	6·6
308·11	+ 0·50	...	6·0		Normæ		16	27	56	−42	36	5·5
308·26	+ 3·56	...	cum. h. 3626		Scorpii	8m	16	16	51	−40	21	8·8
308·28	+ 1·85	...	5·9		,, , Normæ		16	23	22	−41	33	3·3
308·35	+ 8·82	...	4·9		θ Lupi		15	58	43	−36	28	4·4
308·41	−11·33	...	2·9		α Aræ		17	22	34	−49	46	7·7
308·51	+17·95	3·9	3·8	40	τ Libræ, Scorpii		15	31	17	−29	22	9·9
308·79	+12·26	4·5	5·2 *d*		ξ Lupi		15	49	13	−33	36	8·8
308·92	+19·85	5·3	5·7	36	Libræ, Scorpii		15	27	21	−27	38	5·5
309·16	+ 4·72	...	5·8		Scorpii		16	15	54	−38	54	6·6
309·31	+19·46	3·9	3·9	39	υ Libræ, Scorpii		15	29	44	−27	44	2·2
309·56	−12·25	...	5·6		Aræ		17	31	8	−49	20	3·3
309·66	− 8·82	...	5·8		ι ,,		17	14	16	−47	20	9·9
309·91	− 7·73	...	6·1		,,		17	9	56	−46	30	6·6
310·40	+ 5·79	...	5·7		Scorpii		16	16	32	−37	17	0·0
310·61	− 1·61	...	5·8		ζ_1 ,,		16	45	32	−42	9	6·6
310·65	+ 0·70	...	5·9		,,		16	36	24	−40	36	7·7
310·70	− 1·69	...	3·6		ζ_2 ,,		16	46	8	−42	9	2·2
310·77	− 5·35	...	5·7		,,		17	2	1	−44	24	0·0
311·05	− 1·26	...	cum. 5m5h. 3652		,,	6m·6	16	45	37	−41	36	3·3
311·05	−16·30	...	3·9		θ Aræ		17	57	17	−50	5	8·8
311·10	+10·74	...	6·0		Scorpii		16	2	11	−33	13	5·5
311·19	− 0·54	...	5·9		,,		16	43	12	−41	1	3·3
311·37	− 8·42	...	5·7 *d*		Aræ		17	18	1	−45	44	0·0
311·39	−24·83	...	5·2		λ Telescopii		18	48	52	−53	5	6·6
311·65	−10·05	...	5·		σ Aræ		17	26	44	−46	25	2·2

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.			Star.		α 1880. h	m	s	δ 1880. °	′	″
°	°	m	m										
311·81	−11·09	...	6·3			Aræ		17	32	17	−46	51	2
311·98	−23·74	...	5·7		κ	Telescopii		18	43	8	−52	14	6
311·98	− 4·77	...	3·6		η	Scorpii		17	3	34	−43	4	7
312·02	+ 1·35	...	6·0			,,		16	38	36	−39	9	3
312·03	+15·80	4·0	4·5	5	ρ	,,		15	49	29	−28	51	7
312·11	− 1·01	...	6·5 cum.			,,		16	48	15	−40	37	7
312·51	− 7·08	...	5·8			,,		17	15	31	−44	2	7
312·64	+ 3·92	...	6·2			,,		16	31	4	−36	58	4
312·60	−10·13	...	7·0			Aræ		17	30	2	−45	40	8
312·90	−10·04	? var. M. N. 38, 330				,,	? Nova 1862	17	30	30	−45	23	
312·85	+22·31	5·2	5·7	42		Libræ		15	33	11	−23	25	6
313·02	− 0·03	...	cum. h. 3654			Scorpii	$7^{m}\cdot0$	16	47	23	−39	18	5
313·44	+ 6·76	...	4·6		N	,,		16	23	33	−34	26	5
313·45	+19·25	4·8	5·3	1	b	,,		15	43	46	−25	23	1
313·61	−19·13	...	4·5		ζ	Telescopii		18	19	35	−49	8	0
313·67	+ 1·47	...	3·6		μ_1	Scorpii		16	43	45	−37	50	4
313·72	+ 5·64	...	4·4		H	,,		16	28	29	−35	0	4
313·75	+ 1·41	...	3·9		μ_2	,,		16	44	13	−37	48	6
313·88	+18·19	5·5	6·3	4		,,		15	48	15	−25	54	6
314·21	+19·17	4·7	5·2	2	A	,,		15	46	25	−24	58	0
314·22	+13·54	5·1	5·8			,,		16	3	35	−29	5	9
314·40	−18·47	...	6·2			Telescopii		18	17	47	−48	10	8
314·47	+11·19	5·4	5·8 *d*			Scorpii		16	11	57	−30	36	9
314·57	+17·79	3·1	3·4	6	π	,,		15	51	36	−25	46	0
314·80	− 8·41	...	2·1		θ	,,		17	28	42	−42	55	1
314·84	+19·71	5·6	5·8			,,		15	46	44	−24	10	4
315·00	− 2·56	...	5·9			,,		17	3	59	−39	21	3
315·07	− 0·43	...	6·5			,,		16	55	40	−37	58	7
315·14	+14·06	5·5	6·1	12	c_1	,,		16	4	51	−28	6	2
315·24	+20·11	5·4	5·8			,,		15	46	47	−23	37	2
315·26	−15·13	...	5·2		ε	Telescopii		18	2	19	−45	58	4
315·33	− 0·26	...	...			Scorpii	$7^{m}\cdot1$	16	55	48	−37	40	3
315·45	+18·77	5·4	6·1			,,		15	51	23	−24	29	0
315·48	+17·28	5·4	5·7			,,		15	56	6	−25	31	7
315·48	−12·13	...	5·4			,,		17	48	2	−44	19	2
315·50	+14·40	4·7	5·3	13	c_2	,,		16	4	55	−27	36	8
315·91	+13·03	5·0	5·5		*d*	,,		16	10	51	−28	18	8
315·98	+16·20	5·8	6·0			,,		16	0	49	−26	0	2

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.			Star.	α 1880. h	m	s	δ 1880. °	′	″
316·14	+11·24	5·4	5·9 *d*			Scorpii	16	17	8	−29	25	3
316·36	+ 4·14	2·2	2·3	26	ε	„	16	42	24	−34	4	4
316·47	−17·60	...	3·5		α	Telescopii	18	18	4	−46	1	9
316·88	−18·34	...	5·7		δ_1	„	18	22	52	−45	59	6
317·05	−18·32	...	5·7		δ_2	„	18	23	9	−45	50	3
317·20	−13·27	...	5·6			Coronæ aust.	17	58	9	−43	25	7
317·25	−15·08	...	5·9			„ „	18	7	8	−44	14	4
317·37	+20·09	2·5	2·4	7	δ	Scorpii	15	53	14	−22	16	7
317·62	−21·92	...	5·9			Telescopii	18	43	32	−46	44	1
317·64	+18·45	...	6·2			Scorpii	15	58	57	−23	16	7
317·91	−10·99	...	5·3			„	17	49	16	−41	41	8
318·03	−16·40	...	5·7			Coronæ aust.	18	15	34	−44	10	1
318·30	− 8·53	...	3·3		ι_1	Scorpii	17	39	11	−40	4	7
318·37	+ 3·30	...	6·0	27		„	16	49	22	−33	4	0
318·37	+ 1·89	...	5·5		*k*	„	16	56	56	−33	57	1
318·43	− 5·92	...	4·7		Q	„	17	28	17	−38	32	9
318·51	− 0·97	...	6·1			„	17	8	21	−35	36	0
318·59	− 8·93	...	5·6		ι_2	„	17	41	48	−40	3	0
318·66	+14·62	3·0	3·4	20	σ	„	16	13	54	−25	18	2
318·72	− 7·11	...	2·6		κ	„	17	34	11	−38	58	0
318·90	− 4·23	2·8	3·2	34	υ	„	17	22	36	−37	11	9
318·95	+10·43	2·9	3·2	23	τ	„	16	28	25	−27	57	9
319·09	−12·93	1·1	1·4	21	α	„ (Antares)	16	22	3	−26	9	8
319·20	−17·40	...	6 1			Coronæ aust.	18	23	16	−43	35	3
319·23	+ 5·18	...	cum.			Scorpii $6^m·9$	16	47	27	−31	12	2
319·38	− 4·59	1·7	2·0	35	λ	„	17	25	28	−37	0	9
319·40	− 0·92	...	6·1			„	17	10	47	−34	51	2
319·45	−13·00	...	6·2			Coronæ aust.	18	2	35	−41	22	7
319·55	+ 3·60	5·3	5·7			Scorpii	16	54	7	−31	57	8
319·64	+15·68	4·7	5·1	19	ο	„	16	13	25	−23	52	7
319·66	−13·34	...	5·9			Coronæ aust.	18	4	43	−41	21	7
319·93	+20·17	4·6	4·6	10	ω_2	Scorpii	16	0	22	−20	32	6
319·98	+20·41	4·1	4·4	9	ω_1	„	15	59	47	−20	20	6
319·96	+17·10	var. in cum. Mess 80			T	„ Nova 1860 $7^m·0$	16	9	54	−22	40	7
320·10	−18·55	...	5·8			Coronæ aust.	18	30	58	−43	17	2
320·14	+ 0·50	...	5·8			Scorpii	17	7	27	−33	24	5
320·30	−20·28	...	5·7		η_1	Coronæ aust.	18	40	11	−43	48	5
320·40	+21·24	2·9	2·5 *d*	8	β	Scorpii	15	58	28	−19	28	5

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h m s	δ 1880. ° ′ ″
°	°	m	m					
320·44	+ 13·44	4·6	5·3	22	i Scorpii		16 22 55	−24 51·0
320·47	− 17·16	...	5·1		θ Coronæ aust.		18 24 56	−42 23·8
320·53	− 6·05	...	6·2		Scorpii		17 34 42	−36 53·0
320·59	− 20·31	...	6·0		η_2 Coronæ aust.		18 40 57	−43 33·9
320·99	+ 15·34	5·3	5·5 *d*	5	ρ Ophiuchi		16 18 23	−23 10·1
321·08	+ 0·73	...	5·9		Scorpii		17 9 15	−32 31·5
321·19	− 7·28	...	3·4		G „		17 41 41	−37 0·2
321·79	− 21·19	...	5·8		Coronæ aust.		18 47 44	−42 51·6
321·81	+ 20·37	4·2	4·3 *d*	14	ν Scorpii		16 5 1	−19 8·8
321·83	+ 3·50	...	6·2		„		17 1 8	−30 14·6
322·84	− 15·87	...	5·6		Coronæ aust.		18 24 0	−39 47·1
322·90	− 22·17	...	5·2		ζ „ „		18 54 37	−42 15·8
322·93	− 13·67	...	5·6		„ „		18 14 2	−38 42·5
323·17	− 14·89	...	6·0		„ „		18 20 9	−39 3·9
323·27	− 2·26	...	5·8		Scorpii		17 26 52	−32 29·8
323·40	+ 17·88	4·6	4·8	4	ψ Ophiuchi		16 17 5	−19 45·3
323·43	− 18·85	...	5·5		μ Coronæ aust.		18 39 21	−40 31·9
323·57	+ 15·52	4·7	4·7	9	ω Ophiuchi		16 25 1	−21 12·5
323·41	− 6·78	...	cum. Mess 7		Scorpii	$6^m·8$	17 45 23	−34 51·8
323·57	− 7·34	...				7 ·5	17 48 7	−35 1·5
323·71	− 6·35	...				7 ·1	17 44 21	−34 23·0
324·12	− 6·78	...				7 ·5	17 47 12	−34 15·8
323·85	− 15·64	...	5·4 *d*		κ Coronæ aust.		18 25 7	−38 48·3
323·90	− 18·08	...	5·6		„ „		18 36 37	−39 48·3
323·92	− 2·41	...	cum. Mess. 6		Scorpii	$7^m·2$	17 29 10	−32 2·9
324·21	− 2·99	...				6 ·7	17 32 12	−32 7·9
324·31	− 3·17	...				6 ·8	17 33 9	−32 8·9
324·23	− 11·98	3·0	3·3		η Sagittarii		18 9 30	−36 47·7
324·63	+ 0·57	4·4	4·6	45	*d* Ophiuchi		17 19 42	−29 45·4
324·80	− 12·87	...	6·0		Sagittarii		18 14 45	−36 43·4
324·88	− 22·54	...	5·0		δ Coronæ aust.		19 0 0	−40 40·8
324·97	+ 8·32	...	6·1	26	Ophiuchi		16 52 49	−24 48·3
325·12	+ 18·40	5·0	4·6	7	χ „		16 20 4	−18 10·9
325·12	− 17·32	...	5·4		λ Coronæ aust.		18 35 33	−38 26·2
325·25	− 12·78	...	6·2		Sagittarii		18 15 23	−36 17·7
325·54	+ 2·27	5·6	5·8	43	Ophiuchi		17 15 49	−28 1·5
325·68	− 4·36	...	5·5		Scorpii, Sagittarii		17 41 23	−31 39·6
325·79	+ 4·62	4·7	4·9 *d*	36 A	Ophiuchi		17 7 58	−26 25·5

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.	Star.	α 1880. h	m	s	δ 1880. °	′
°	°	m	m						
325·96	+ 10·05	5·6	5·9	24 Ophiuchi	16	49	34	−22	57·5
326·14	+ 22·79	6·0	6·3	Scorpii	16	9	5	−14	32·8
326·17	− 22·43	...	4·1	β Coronæ aust.	19	1	46	−39	31·8
326·30	+ 14·78	5·7	6·0	Ophiuchi, Scorpii	16	34	51	−19	41·6
326·61	− 10·72	...	6·5	Sagittarii	18	9	39	−34	8·8
326·75	− 20·82	...	6·1	Coronæ aust.	18	55	6	−38	25·5
327·01	− 12·05	2·1	2·2	20 ε Sagittarii	18	16	12	−34	26·4
327·13	− 19·26	...	5·7	Coronæ aust.	18	48	32	−37	29·7
327·27	+ 18·85	4·4	4·6	8 φ Ophiuchi	16	24	16	−16	21·0
327·53	− 19·55	...	5·5	ε Coronæ aust.	18	50	38	−37	15·7
327·58	− 21·82	...	4·2	α „ „	19	1	18	−38	5·4
327·66	+ 12·36	...	6·1	Ophiuchi	16	46	20	−20	12·8
327·71	− 16·31	...	5·2	Sagittarii	18	36	17	−35	45·5
327·76	− 19·96	...	6·2 *d*	Coronæ aust.	18	32	57	−37	13·5
327·93	+ 4·32	3·4	3·6	42 θ Ophiuchi	17	14	38	−24	52·7
327·99	+ 5·48	5·2	5·5 *d*	39 ο „	17	10	42	−24	9·3
328·02	+ 16·21	5·2	5·5	„ , 24 Scorpii	16	34	38	−17	30·5
328·02	− 5·41	...	5·4	Sagittarii	17	51	23	−30	14·3
328·14	+ 1·81	...	6·2	Ophiuchi	17	24	17	−26	10·6
328·19	− 20·95	...	4·6 *d*	γ Coronæ aust.	18	58	18	−37	14·0
328·27	+ 25·14	...	5·6	17 χ Scorpii	16	7	13	−11	31·8
328·40	+ 20·79	5·8	6·1	Ophiuchi	16	23	0	−14	17·2
328·64	− 6·74	3·0	2·8	10 γ Sagittarii	17	58	6	−30	25·4
328·77	− 1·99	var.	4 −6	3 X „	17	40	0	−27	47·0
328·82	− 7·70	5·7	5·9 *d*	„	18	2	21	−30	44·8
328·95	− 12·69	...	5·8	„	18	23	12	−33	4·0
329·18	+ 4·00	4·5	4·5	44 *b* Ophiuchi	17	19	2	−24	3·8
329·20	− 13·24	...	5·6	Sagittarii	18	26	5	−33	6·2
329·27	− 4·56	5·8	6·2	„	17	51	2	−28	44·6
329·27	− 6·17	var.	5 −6·5	W „	17	57	21	−29	35·0
329·64	− 3·83	5·8	6·0	„	17	49	7	−28	2·7
329·99	+ 22·35	var.	7·0−10	V Ophiuchi	16	20	3	−12	9·2
330·01	+ 3·17	4·9	5·2	51 *c* „	17	24	6	−23	52·1
330·37	− 10·52	5·7	6·0	Sagittarii	18	17	19	−30	49·0
330·59	− 6·18	4·7	5·1	„	18	0	29	−28	28·1
330·78	− 9·33	2·8	2·8	19 δ „	18	13	19	−29	52·6
330·99	+ 6·77	4·5	5·1	40 ξ Ophiuchi	17	13	49	−20	59·0
331·40	+ 16·67	...	6·1	„	16	41	38	−14	41·7

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1830. h m s	δ 1830. ° ′ ″
331·50	−10·61	6·0	6·2		Sagittarii		18 20 9	−29 53·2
331·97	+ 4·71	...	...		Ophiuchi	Nova 1604	17 23 27	−21 22·6
332·92	− 7·40	4·7	5·1		Sagittarii		18 10 33	−27 5·1
333·27	+21·50	2·8	2·6	13 ζ	Ophiuchi		16 30 33	−10 19·4
333·29	+12·23	var.	7·0−?	R	„		17 0 52	−15 55·9
333·44	+ 2·11	5·0	5·4	58	„		17 36 14	−21 37·4
333·60	− 3·05	5·4	5·9	7	Sagittarii		17 55 30	−24 16·8
333·61	+ 8·90	...	6·1		Ophiuchi		17 12 54	−17 37·8
333·63	+24·66	4·6	5·2	3 ν	Ophiuchi		16 21 19	− 8 6·1
333·64	− 2·21	4·6	5·4	4	Sagittarii		17 52 28	−23 48·0
333·65	− 3·29	5·7	6 o cum.	9	„		17 56 31	−24 21·7
333·77	− 3·57	...	6·5 neb.		„		17 57 49	−24 24·2
333·91	−18·25	5·5	5·9		„		18 56 43	−31 13·3
333·97	+11·94	2·6	2·4	35 η	Ophiuchi		17 3 30	−15 34·5
334·50	− 1·89	...	7·1		Sagittarii		17 55 15	−22 54·1
334·77	− 2·09	5·8	6·3		„		17 54 38	−22 46·5
334·76	+15·72	var.	5·5−12		Ophiuchi, Nova 1848		16 52 47	−12 42·4
334·86	−17·42	2·9	3·1	38 ζ	Sagittarii		18 54 58	−30 3·0
335·08	+18·88	4·7	5·1	20	„		16 43 12	−10 34·2
335·13	− 4·50	5·3	5·7		Sagittarii		18 4 24	−23 43·4
335·18	− 7·04	6·6	var.		„		18 14 8	−24 58·0
335·29	− 2·41	...	6·8		„		17 56 57	−22 30·2
335·46	− 8·57	3·1	2·7	22 λ	„		18 20 34	−25 29·2
335·89	−12·80	3·3	3·7	27 φ	„		18 38 10	−27 6·7
336·91	+23·74	6·0	6·4		Ophiuchi		16 31 36	− 6 17·7
337·15	− 4·01	5·9	6·0	14	Sagittarii		18 7 3	−21 44·6
337·33	− 9·09	5·9	5·9	24	„		18 26 34	−24 7·2
337·39	−17·36	3·5	3·6	40 τ	„		18 59 27	−27 50·7
337·51	−14·42	2·3	2·4	34 σ	„		18 47 49	−26 26·6
337·62	−11·75	5·7	6·2		„		18 37 27	−25 7·8
337·66	− 3·59	4·1	4·3	13 μ	„		18 6 35	−21 5·3
337·70	− 9·53	...	neb. Moss 22		„	$6^m{\cdot}1$	18 29 1	−24 0·2
337·86	+11·49	4·4	4·6	53 ν	Serpentis		17 14 5	−12 43·4
337·99	+ 6·69	3·7	3·7	55 ξ	„		17 30 43	−15 19·3
338·12	− 3·71	5·6	5·8	15	Sagittarii		18 8 3	−20 45·7
338·27	+15 03	5·6	5·8		Ophiuchi		17 3 10	−10 21·9
338·30	− 9·78	5 8	6·1		Sagittarii		18 31 13	−23 36·3
338·84	−21·00	5·9	5·9		„		19 17 1	−28 5·8

Galactic Long.	Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h m s	δ 1880. ° ′ ″
°	°	m	m					
339·46	− 5·68	4·9	5·1	21	Sagittarii		18 18 12	−20 36·3
339·52	+ 0·92	6·1	6·9	6	,,		17 54 25	−17 9·1
339·60	−15·25	5·7	6·1		,,		18 55 7	−25 0·6
339·81	+20·60	5·6	5·8	23	Ophiuchi		16 48 11	− 5 57·4
339·86	+ 5·02	...	6·1		Serpentis		17 40 46	−14 40·7
339·94	− 2·74	...	6·5		Sagittarii		18 8 28	−18 41·8
340·04	+ 2·66	5·9	5·9		Serpentis, Ophiuchi		17 49 25	−15 47·4
340·12	− 8·66	...	6·2		Sagittarii		18 30 43	−21 29·7
340·15	−10·86	5·6	5·6	28	,,		18 39 6	−22 31·0
340·31	− 0·39	5·9	5·9		,,		18 0 51	−17 10·1
340·35	− 3·04	cum. Mess 24			,,	$6^{m}\cdot9$	18 10 26	−18 30·2
340·36	− 3·37					7 ·2	18 11 40	−18 39·8
340·46	− 4·04	var.		Y	,,		18 14 19	−18 54·7
340·47	−13·20	5·9	6·4		,,		18 48 45	−23 19·5
340·52	−18·11	5·2	5·4	42	ψ ,,		19 8 11	−25 27·7
340·54	− 8·70	6·0	6·0		,,		18 31 44	−21 9 0
340·62	+ 7·27	4·4	4·7	56	o Serpentis		17 34 40	−12 48·6
340·67	−12·63	5·0	5·0	32	ν_1 Sagittarii		18 46 55	−22 53·5
340·84	−12·78	5·2	5·1	35	ν_2 ,,		18 47 52	−22 49·2
340·85	−11·68	6·1	6 6	30	,,		18 43 38	−22 17·9
341·13	+ 9·52	6·0	5·8		Serpentis		17 28 6	−11 9·6
341·26	− 2·44	...	6·4		Sagittarii		18 10 13	−17 24·8
341·45	− 6·34	var.	7·0−83	U	,,		18 24 49	−19 12 4
341·61	− 5·79	5·7	6·0		,,		18 23 9	−18 48·2
341·85	+ 8·99	...	6·1		Serpentis		17 31 30	−10 51·2
341·92	−11·96	6·0	6·0	33	Sagittarii		18 46 50	−21 30·3
342·04	− 5·89	5·2	5·5		,,		18 24 24	−18 29·0
342·20	−19·82	5·1	5·4	47	χ_1 ,,		19 17 58	−24 44·4
342·38	−10·59	5·5	5·5	29	,,		18 42 33	−20 27·6
342·49	+20·35	5·0	5·5	30	Ophiuchi		16 54 44	− 4 2·5
342·55	−12·63	3·5	3·5	37	ξ_2 Sagittarii		18 50 34	−21 15·8
342·70	−14·35	3·9	3·8	39	o ,,		18 57 29	−21 54·9
342·75	−19·64	5·9	5·6	49	χ_2 ,,		19 18 14	−24 11·8
342·92	−12·34	5·0	5·7	36	ξ_1 ,,		18 50 13	−20 48·7
342·95	− 2·28	5·8	5·8		,,	Serpentis	18 13 14	−15 52·7
342·95	−22·34	4·6	4·7	52	h_2 ,,		19 29 24	−25 8·8
343·05	−22·14	5·8	var.	51	h_1 ,,		19 28 44	−24 58·8

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h	α 1880. m	α 1880. s	δ 1880. °	δ 1880. ′	δ 1880. ″
°	°	m	m									
343·76	−17·97	5·7	5·9			Sagittarii	19	13	26	−22	37	4
343·92	−15·10	3·1	3·1	41	π	„	19	2	38	−21	12	8
344·22	+10·55	4·7	4·7	57	μ	Ophiuchi	17	31	19	− 8	2	7
344·53	− 0·94	...	neb. Mess. 16			Serpentis	8m.	18	11	48	−13	50
344·84	−12·90	5·9	6·4			Sagittarii		18	56	1	−19	25·0
344·94	−18·90	5·5	5·9	50		„		19	19	10	−22	0·8
345·14	− 3·54	4·7	4·8	2	Hev.	Scuti		18	22	21	−14	38·4
345·29	− 4·44	5·8	5·9			„		18	25	52	−14	57·1
345·34	+14·52	4·6	4·5	27	Hev.	Ophiuchi		17	20	16	− 4	58·8
345·36	−14·02	5·5	5·8			Sagittarii		19	1	14	−19	28·6
345·41	− 4·63	5·8	6·4			Scuti		18	26	48	−14	56·5
345·42	+13·15	5·8	5·9			Ophiuchi		17	27	5	− 5	39·3
345·57	+ 5·24	3·5	3·5	64		„		17	52	25	− 9	45·5
345·63	+20·52	6·2	6·6			„		17	0	40	− 1	29·6
345·74	−13·53	...	6·7			Sagittarii		19	0	7	−18	55·6
345·81	− 0·06	cum.	VIII. 15			Serpentis	7m.	18	11	22	−12	17·1
346·13	+21·21	5·6	5·9			Ophiuchi		16	59	21	− 0	43·6
346·34	+20·54	5·9	6·3			„		17	2	2	− 0	55·2
346·61	− 9·99	5·6	5·8			Sagittarii		18	48	36	−16	31·3
346·63	− 1·02	5·9	6·0			Scuti		18	16	29	−12	4·3
346·69	−15·85	4·9	5·6	43	*d*	Sagittarii		19	10	37	−19	9·9
347·45	+ 5·19	4·9	5·3 *d*	69	τ	Ophiuchi		17	56	33	− 8	10·7
347·71	+ 4·47	...	6·2			Serpentis		17	59	35	− 8	19·9
347·76	−16·45	6·1	6·5	45		Sagittarii		19	14	51	−18	31·7
347·80	− 9·46	5·1	5·5			Scuti, Sagittarii		18	47	50	−15	45·1
347·87	+ 8·45	var.	6·2−7·0		Y	Ophiuchi		17	46	13	− 6	6·8
348·02	−12·35	5·8	6·0			Sagittarii		18	59	58	−16	24·7
348·09	+19·09	5·0	5·1	41		Ophiuchi		17	10	27	− 0	18·5
348·17	−16·22	3·9	4·2	44	ρ	Sagittarii		19	14	43	−18	4·3
348·39	−11·82	6·0	5·9			„		18	58	49	−15	50·4
348·69	− 2·17	...	6·1 *d*			Scuti		18	24	46	−10	52·6
348·96	− 3·03	5·3	5·7			„		18	28	22	−11	4·1
349·00	−22·32	5·1	5·2	56	*f*	Sagittarii		19	39	22	−20	2·9
349·36	+ 0·41	5·0	5·3	1	Hev.	Scuti		18	17	5	− 8	59·7
349·41	+15·83	5·4	5·7 *d*			Ophiuchi		17	24	13	− 0	57·7
349·48	+20·11	var.	6·0−6·7		U	„		17	10	26	+ 1	20·7
349·48	−19·68	6·0	5·8			Sagittarii		19	30	6	−18	29·8

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
349·92	+ 7·64	6·0	6·1		Ophiuchi, Serpentis	17	53	14	− 4	48	5
349·93	− 15·39	4·7	4·9	46 υ	Sagittarii	19	14	51	− 16	10	7
350·20	+ 8·62	5·7	5·8		Ophiuchi, Serpentis	17	50	28	− 4	3	8
350·21	− 9·15	5·3	5·6		Sagittarii	18	52	39	− 13	0	1
350·44	+ 16·87	5·2	5·6		Ophiuchi	17	22	42	+ 0	25	8
350·82	+ 6·25	5·8	6·0		Serpentis	17	59	52	− 4	45	6
351·01	+ 8·03	4·5	4·9	57 ζ	,,	17	54	9	− 3	40	9
351·11	− 5·13	5·8	6·2		Scuti	18	40	6	− 10	15	1
351·27	− 15·94	5·7	5·9		Sagittarii	19	19	21	− 15	17	4
351·37	− 1·72	4·0	3·6	3 Hev.	Scuti, 1 Aquilæ	18	28	41	− 8	19	6
351·52	− 3·65	4·8	5·1	4 Hev.	,, 2 ,,	18	35	42	− 9	10	0
351·74	− 19·62	5·6	5·5	54 e_1	Sagittarii	19	33	51	− 16	34	0
352·10	− 19·93	5·0	5·4	55 e_2	,,	19	35	39	− 16	24	2
352·24	− 15·24	5·8	5·9		,,	19	18	35	− 14	8	0
352·33	− 11·88	5·8	5·8		,,	19	6	33	− 12	29	0
352·35	− 3·54	5·1	5·2	5 Hev.	Scuti, 3 Aquilæ	18	36	59	− 8	23	5
352·50	− 19·74	5·5	5·8		Sagittarii	19	36	43	− 15	44	8
352·93	+ 17·54	5·6	5·9		Ophiuchi	17	25	20	+ 2	48	9
353·27	− 18·06	5·6	5·8		Sagittarii	19	30	49	− 14	33	8
353·60	+ 19·29	4·5	4·7	49 σ	Ophiuchi	17	20	34	+ 4	14	8
354·31	+ 11·11	5·8	6·1		,,	17	50	12	+ 0	41	4
354·34	+ 3·90	3·4	3·5	58 η	Serpentis	18	15	6	− 2	55	7
354·45	− 23·00	5·0	5·3	61 g	Sagittarii	19	51	9	− 15	48	5
354·53	+ 14·62	5·8	5·9 d	61	Ophiuchi	17	38	33	+ 2	39	0
355·05	+ 13·95	3·8	3·8	62 γ	,,	17	41	53	+ 2	45	2
355·02	− 4·22	...	cum.neb.Mess.11		Scuti	7m·	18	44	42	− 6	25	1
355·08	− 3·14	var.	4·7 − 9·0	R	,,		18	41	5	− 5	49	9
355·56	+ 10·25	4·4	5·1	68	Ophiuchi	17	55	40	+ 1	18	6
355·87	− 2·61	4·4	4·5	6 Hev.	Scuti, 6 Aquilæ	18	40	48	− 4	52	5
356·12	− 5·29	5·1	5·4	7 Hev.	,, ,9 ,,	18	50	38	− 6	0	0
356·15	+ 2·56	5·5	5·8	60 o	Serpentis	18	23	26	− 2	3	7
356·15	− 9·70	5·3	5·9	20	Aquilæ	19	6	10	− 8	8	3
356·16	+ 15·82	2·9	2·8	60 β	Ophiuchi	17	37	33	+ 4	37	1
356·46	− 15·82	5·3	5·8	37	Aquilæ	19	28	30	− 10	49	3
356·71	− 6·22	4·0	3·8	12	,,	18	55	16	− 5	54	4
356·79	+ 21·01	6·0	6·3		Ophiuchi	17	20	31	+ 7	42	1
356·85	+ 11·28	4·0	4·2	67	,,	17	54	38	+ 2	56	3

Galactic Long.	Galactic Lat.	Magn. H.P.	Magn. U.A.		Star.		α 1880. h	m	s	δ 1880. °	′	″
357·10	+10·05	4·1	4·2 *d*	70	Ophiuchi		17	59	23	+ 2	31	7
357·67	+15·31	...	cum.		„	$7^{m}\cdot1$	17	40	48	+ 5	49	5
357·68	+22·13	6·0	6·1		„		17	18	14	+ 8	57	9
357·74	+ 4·16	5·2	5·5 *d*	59 *d*	Serpentis		18	21	4	+ 0	7	6
358·09	+12·07	4·8	5·4	66	Ophiuchi		17	54	19	+ 4	22	6
358·09	− 6·82	3·6	3·3	16 λ	Aquilæ		18	59	53	− 5	3	7
358·14	−19·32	5·6	5·8	51	„		19	44	11	−11	4	0
358·18	+ 9·37	5·7	6·2		Ophiuchi		18	3	54	+ 3	6	4
358·42	+ 1·65	5·8	6·1	*e*	Serpentis		18	31	26	− 0	24	5
358·45	+ 9·30	5·7	5·8		Ophiuchi		18	4	41	+ 3	18	1
358·67	− 6·13	5·6	5·6	15 *h*	Aquilæ		18	58	37	− 4	12	5
358·71	− 5·52	5·5	5·7	14 *g*	„		18	56	35	− 3	52	3
358·78	+14·43	5·9	6·2		Ophiuchi		17	47	24	+ 6	7	6
358·90	+ 9·86	5·7	6·0	73	„		18	3	36	+ 3	58	4
358·97	−12·90	var.	6·3 − 7·3	U	Aquilæ		19	22	54	− 7	17	3
359·11	− 0·60	5·8	6·2 *d*	5	„		18	40	17	− 1	5	2
359·34	−10·20	5·2	5·6	26 *f*	„		19	14	8	− 5	38	3
359·58	− 3·18	6·0	6·5		„		18	50	9	− 1	57	2
359·69	+20·15	5·9	5·8	53 *f*	Ophiuchi		17	28	55	+ 9	40	1
359·71	−25·97	4·5	4·5	5 α_1	Capricorni		20	11	0	−12	52	7
359·72	−26·07	3·8	3·6	6 α_2	„		20	11	24	−12	54	9
359·75	+ 7·10	5·0	5·5	74	Ophiuchi		18	14	53	+ 3	19	4
359·90	−14·54	4·3	4·6	39 κ	Aquilæ		19	30	26	− 7	17	6

Supplementary List.

9·65	−18·15	6·0	6·7	64	Aquilæ		20	1	50	− 1	1	3
11·83	+22·00	5·9	...		Herculis		17	43	16	+20	36	4
13·80	+22·21	5·9	...		„		17	45	45	+22	21	0
18·44	− 5·45	6·1	6·2	48 ψ	Aquilæ		19	38	59	+13	0	9
26·29	−16·75	6·1	6·3	8 θ	Delphini		20	33	4	+12	53	7
26·82	+22·21	5·9	...		Herculis		18	7	22	+33	25	1
31·12	+14·20	6·0	...		Lyræ		18	50	29	+33	49	0
31·46	+12·76	6·1	...		„		18	57	22	+33	27	0
34·71	+10·08	6·1	...		„		19	16	10	+34	57	7
36·58	+11·43	6·1	...		„		19	14	48	+37	13	5
37·95	+17·65	6·1	...		„		18	48	16	+41	14	3

Galactic Long.	Galactic Lat.	Magn. H.F.	Magn. U.A.		Star.	α 1880. h	m	s	δ 1880. °	′	″
°	°	m	m								
44·85	+21·25	6·0	...		Draconis	18	45	6	+48	37	8
47·95	+ 0·21	6·1	...		Cygni	20	35	10	+40	9	3
48·56	+14·68	6·1	...		,,	19	30	23	+49	0	1
49·05	+22·91	5·8	...		Draconis	18	44	2	+52	51	4
49·29	+22·21	5·6	...		,,	18	48	54	+52	49	2
50·67	+ 6·86	6·1	...		Cygni	20	16	7	+46	27	5
68·18	+22·39	5·8	...		Draconis	19	44	28	+69	2	6
73·51	+ 7·50	6·1	...		Cephei	22	8	38	+62	41	9
73·81	+ 6·74	6·2	...	25	,,	22	14	18	+62	12	2
79·36	+22·14	5·8	...		,, 77 Drac.	21	7	52	+77	38	4
81·33	−17·57	6·1	...		Andromedæ	23	55	36	+41	41	9
81·34	−12·50	6·1	...		,,	23	49	30	+46	41	3
81·67	−14·70	6·1	...		,,	23	54	36	+44	35	1
84·24	+11·75	6·2	...		Cephei	23	29	47	+70	58	7
85·03	+ 2·01	6·1	...		Cassiopeiæ	23	58	4	+61	37	2
87·92	− 0·60	6·0	...		,,	0	23	39	+59	19	9
95·33	+22·37	6·0	...		Cephei	2	53	13	+81	0	2
97·50	−16·61	6·1	...		Andromedæ	1	19	16	+42	50	1
100·26	−22·46	5·9	...		,,	1	27	21	+36	37	3
105·34	+21·65	6·0	...		Camelopardi	4	49	33	+73	53	2
106·61	+22·07	5·7	...		,,	5	3	26	+73	7	6
116·15	+23·28	5·3	...	36	,,	6	0	47	+65	44	4
119·76	+ 9·34	6·2	...		,,	4	38	17	+55	23	2
120·64	+22·34	5·4	...	1	Lyncis	6	6	51	+61	33	1
124·20	+22·31	5·5	...	5	,,	6	16	20	+58	28	8
126·32	+21·49	5·4	...		,,	6	16	8	+56	20	8
138·20	+22·47	5·9	...		Aurigæ	6	47	40	+46	25	5
162·88	−22·89	5·7	6·0	5	Orionis	4	47	7	+ 2	18	5
166·51	−17·42	5·4	5·9	21	,,	5	12	56	+ 2	28	2

The following are the galactic longitudes of the points at which the equator, the ecliptic and the parallels + 30° and − 30° of declination cross the parallels of galactic latitude :

Gal. Lat.	Equat.	Decl. +30°		Eclipt.	Equat.	Decl. −30°		Eclipt.	Gal. Lat.
	°	°	°	°	°	°	°	°	
+26	343·64	21·15	158·85	169·92	196·36	247·50	292·50	315·51	+26
24	345·10	22·02	157·98	168·38	194·90	242·75	297·25	317·05	24
22	346·51	22·92	157·08	166·90	193·49	238·86	301·14	318·53	22
20	347·87	23·85	156·15	165·47	192·13	235·54	304·46	319·96	20
18	349·19	24·80	155·20	164·08	190·81	232·62	307·38	321·35	18
16	350·47	25·79	154·21	162·73	189·53	230·00	310·00	322·70	16
14	351·72	26·81	153·19	161·41	188·28	227·64	312·36	324·02	14
12	352·95	27·87	152·13	160·12	187·05	225·48	314·52	325·31	12
10	354·16	28·98	151·02	158·85	185·84	223·48	316·52	326·58	10
8	355·35	30·12	149·88	157·60	184·65	221·62	318·38	327·82	8
6	356·52	31·32	148·68	156·37	183·48	219·88	320·12	329·06	6
4	357·69	32·57	147·43	155·14	182·31	218·25	321·75	330·28	4
+ 2	358·84	33·89	146·11	153·93	181·16	216·72	323·28	331·50	+ 2
0	0·00	35·26	144·74	152·71	180·00	215·26	324·74	332·71	0
− 2	1·16	36·72	143·28	151·50	178·84	213·89	326·11	333·93	− 2
4	2·31	38·25	141·75	150·28	177·69	212·57	327·43	335·14	4
6	3·48	39·88	140·12	149·06	176·52	211·32	328·68	336·37	6
8	4·65	41·62	138·38	147·82	175·35	210·12	329·88	337·60	8
10	5·84	43·48	136·52	146·58	174·16	208·98	331·02	338·85	10
12	7·05	45·48	134·52	145·31	172·95	207·87	332·13	340·12	12
14	8·28	47·64	132·36	144·02	171·72	206·81	333·19	341·41	14
16	9·53	50·00	130·00	142·70	170·47	205·79	334·21	342·73	16
18	10·81	52·62	127·38	141·35	169·19	204·80	335·20	344·08	18
20	12·13	55·54	124·46	139·96	167·87	203·85	336·15	345·47	20
22	13·49	58·86	121·14	138·53	166·51	202·92	337·08	346·90	22
24	14·90	62·75	117·25	137·05	165·10	202·02	337·98	348·38	24
−26	16·30	67·50	112·50	135·51	163·64	201·15	338·85	349·92	−26

Gould's investigation places the pole of the galactic circle in α $12^h\ 41^m\ 20^s$ δ $+27°\ 21'$ for 1875 (Uran. Arg. p. 371) and that of the belt of bright stars in α $11^h\ 25^m$ δ $+\ 30°$ (p. 356), the medial line of the belt being 92°·3 from the pole (p. 362). The following are the galactic latitudes of the points at which the longitude-circles of the adopted system are crossed by Gould's galactic great circle, by its + 20° and − 20° parallels, and by the great circle and the medial line of the belt of stars:

Gal. Long.	Gould's Galactic Circle.			Belt.	
	+20°	0°	−20°	0°	−2°·8
°	°	°	°	°	°
0	+19·67	−0·35	−20·37	+16·1	+13·3
10	20·14	+0·12	19·90	15·7	12·9
20	20·61	0·59	19·44	14·8	11·9
30	21·06	1·04	18·98	13·4	10·6
40	21·47	1·45	18·56	11·7	8·8
50	21·84	1·83	18·19	9·5	6·7
60	22·15	2·14	17·87	7·1	4·2
70	22·40	2·40	17·61	4·4	+ 1·5
80	22·58	2·58	17·43	+ 1·6	− 1·4
90	22·68	2·68	17·32	− 1·3	− 4·2
100	22·70	2·70	17·30	4·2	7·1
110	22·64	2·64	17·37	6·9	9·8
120	22·50	2·49	17·51	9·3	12·2
130	22·28	2·28	17·73	11·5	14·4
140	22·00	1·99	18·02	13·3	16·1
150	21·66	1·64	18·37	14·7	17·5
160	21·27	1·25	18·77	15·6	18·4
170	20·83	0·81	19·21	16·1	18·9
180	+20·37	+0·35	−19·67	−16·1	−18·9
190	19·90	−0·12	20·14	15·7	18·5
200	19·44	0·59	20·61	14·8	17·6
210	18·98	1·04	21·06	13·4	16·3
220	18·56	1·45	21·47	11·7	14·5
230	18·19	1·83	21·84	9·5	12·3
240	17·87	2·14	22·15	7·1	10·0
250	17·61	2·40	22·40	4·4	7·3
260	17·43	2·58	22·58	− 1·6	− 4·5
270	17·32	2·68	22·68	+ 1·3	− 1·6
280	17·30	2·70	22·70	4·2	+ 1·3
290	17·37	2·64	22·64	6·9	4·0
300	17·51	2·49	22·50	9·3	6·5
310	17·73	2·28	22·28	11·5	8·6
320	18·02	1·99	22·00	13·3	10·5
330	18·37	1·64	21·66	14·7	11·9
340	18·77	1·25	21·27	15·6	12·8
350	19·21	0·81	20·83	16·1	13·3
0	+19·67	−0·35	−20·37	+16·1	+13·3

The preparation of the catalogue of galactic positions has already consumed so much time, on account of its repeated extensions and the consequent rearrangements and transpositions, that at present I cannot spare the additional time required for a final independent re-examination of all the data, so that I must beg of those who make use of the catalogue to be good enough to communicate any errors or discrepancies which they may find. Mr. Ant. Pannekoch, of Leiden, has already done so by kindly sending me a list of errors, which the laying down of the published galactic positions and the comparison with the usual star maps had led him to remark and to examine. A portion of these errors and some additional ones I had already found, so that the following "List of Corrections" may perhaps not be very defective:

Page	78	2·56+3·85 delete. The correct galactic position of 60 Serpentis is 356·15+2·56 and will be found in its place.
	79	13·55−19·14 lat. should be +19·14.
		13·86−1·16 ω Aquilæ, not α.
		14·76−11·35 lat. should be −1·15.
		15·70+16·07 should be 16·68+15·07.
	80	18·49+15·64 ,, 19·34+14·00.
	81	24·27+18·36 ,, 24·52+18·02.
		24·52+17·72 lat. should be −17·72.
	82	28·30+20·48 ,, ,, −20·48.
	83	31·25+15·12 ,, ,, −15·12.
	90	71·91−15·57 ,, ,, +15·57.
	91	78·30−16·30 ,, ,, +16·30.
	98	117·87−10·61 long. should be 127·87, so that the position should be inserted on the next page.
	100	135·10−21·91 lat. should be +21·91.
	104	157·17−3·55 long. ,, 153·17.
	105	158·23+2·47 delete. The correct position of 21 Orionis is found at the end of the supplementary list.
	106	162·95−20·97 insert H. P. Mag. 6·0.
	108	173·87−18·99 lat. should be +18·99.

Colonel Cooper's Observatory,
Markree, Collooney, Ireland.

Erratum in Mr. Prince's paper, vol. liii. p. 342. fourth line from bottom, *for* $8^m\ 30^s$ *read* 8′ 30″.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. MAY 12, 1893. No. 7

Captain W. de W. ABNEY, C.B., R.E., D.C.L., F.R.S., President, in the Chair.

Walter Frederick Gale, M.R.S. of N.S.W., The Observatory, Paddington, New South Wales, Australia;
The Rev. P. H. Kempthorne, M.A., Wellington College, Berks;
James Henry Young, B.Sc. (Lond.), The Dell, Tooting Graveney, Surrey,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

William Murray Dobie, M.D., J.P., Northgate House, Chester (proposed by George Knott);
Roland Pillans, Geodetic Survey, Royal Observatory, Cape of Good Hope (proposed by David Gill);
Dr. Charles Lane Poor, Astronomer in the Johns Hopkins University, Baltimore, M.D., U.S A. (proposed by Harold Jacoby);
Thomas Jefferson Jackson See, Ph.D., University, Chicago, U.S.A. (proposed by S. W. Burnham);
Louis Heathcote Walter, 56 Victoria Street, Westminster, S.W. (proposed by George Calver).

Eighty-two presents were announced as having been received since the last meeting, including, amongst others:—

Greenwich Observations, 1890, presented by the Observatory; Annals of the Cape Observatory, vol. i. part 2, presented by the Observatory; H. Jacoby, the parallaxes of μ and θ *Cassiopeiæ*, deduced from the Rutherfurd photographic measures, presented by the author; Potsdam Astrophysical Observatory, Publications, vol. viii.; Lick Observatory, original negatives of *Jupiter*, and enlargements of photographs of *Jupiter*, &c., presented by the Observatory; Lick Observatory photograph of *Jupiter*, enlargement made and presented by A. Stanley Williams, Esq.; Lick Observatory photographs of the Moon, series of enlargements made and presented by Baron Albert Rothschild; series of photographs made by Dr. Warren De la Rue during the total solar eclipse of 1860 July 18, and a photograph of Dr. De la Rue, presented by Thomas De la Rue, Esq.; a 10-inch brass pillar sextant by Troughton, and a double sextant by Cary, bequeathed by the late A. E. Nevins, Esq.

Note on the Determination of the Moon's Mass. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

In *Gould's Astronomical Journal*, No. 289, Professor G. W. Hill has given a determination of the Moon's mass from the values of the constants of Precession and Nutation which are at present generally accepted.

In this paper the approximations are pushed to the seventh order of small quantities, and although, from the fact that Delaunay's expressions of parallax are only pushed to the fifth order of small quantities, no reliance can be placed on the absolute accuracy of the terms of the sixth and seventh orders, the result is probably the most accurate which has yet been obtained.

But Professor Hill in this paper expresses an opinion that in previous investigations the undisturbed elliptic co-ordinates of the Moon had alone been employed. This is certainly not the case in the investigation, the results of which are given in the *Monthly Notices R.A.S.*, vol. xxviii. p. 42. In this investigation I used Delaunay's co-ordinates, and my results should be identical with Professor Hill's to the order of approximation to which I proceeded, which was the third. On examination I find such to be the case, although the agreement is slightly disguised by the introduction of two different constants ϵ and ϵ', which have to be found from observations by a comparison between the theoretical results and the constants of precession and nutation.

To make the comparison easy between my results and those

which I had obtained from Serret's formulæ, *Monthly Notices*, vol. xxviii. p. 25, I introduced the constant

$$\epsilon = \frac{\text{Moon's mass}}{\text{Sun's mass}} \cdot \frac{(\text{mean distance of Sun})^3}{(\text{mean distance of Moon})^3}.$$

The exact meaning of the expressions "mean distances of the Sun and Moon" being defined by the conditions that if a' and D' denote these distances, a the equatorial radius of the Earth, and π and C the constants of solar and lunar parallax

$$\sin 1'' \cdot \pi = \frac{a}{a'}; \quad \sin 1'' \cdot C = \frac{a}{D}.$$

But Professor Hill has practically introduced a constant

$$\epsilon' = \frac{\text{Moon's mass}}{\text{Sun's mass}} \cdot \frac{a_1^3}{a^3},$$

where a is the constant introduced in Delaunay's Theory as satisfying the condition

$$\text{Moon's mass} = n^2 a^3,$$

where n is the Moon's mean motion in longitude; but we have in *Delaunay's Lunar Theory*, vol. ii. p. 914,

$$\sin 1'' \cdot C = \frac{a}{a}\left(1 + \frac{m^2}{6} + \frac{m^2 e_1^2}{4} - \frac{179}{288}m^4 - \frac{97}{48}m^5\right) = \frac{a}{D}$$

$$\therefore \frac{a}{D} = \left(1 + \frac{m^2}{6} + \frac{m^2 e_1^2}{4} - \frac{179}{288}m^4 - \frac{97}{48}m^5\right)$$

But

$$\frac{\epsilon}{\epsilon_1} = \frac{a^3}{D^3} = \left(1 + \frac{m^2}{6} + \&c.\right)^3$$

or

$$\epsilon = \epsilon'\left(1 + \frac{m^2}{6} + \&c.\right)^3 = \epsilon'\left(1 + \frac{m^2}{2} + \&c.\right)$$

If we substitute this value of ϵ in the equations

$$\text{Luni-solar precession} = \kappa\left(1 + \frac{3e_1^2}{2}\right) + \kappa\epsilon\left(1 + \frac{3e^2}{2} - 6\gamma^2\right)$$

$$\text{Nutation} = \kappa\epsilon\frac{2\gamma}{\mu}\left[1 + \frac{3e^2}{2} - \frac{5\gamma^2}{2}\right]$$

given in my paper, we have to the third order of small quantities

$$\text{Luni-solar precession} = \kappa\left[1 + \frac{3e_1^2}{2}\right] + \kappa\epsilon'\left[1 + \frac{m^2}{2} + \frac{3e^2}{2} - 6\gamma^2\right]$$

$$\text{Nutation} = \kappa\epsilon'\frac{2\gamma}{\mu}\left[1 + \frac{m^2}{2} + \frac{3e^2}{2} - \frac{5\gamma^2}{2}\right],$$

expressions which are identical to the same order of approximation with those given by Professor Hill.

On the Distribution of Temperature in the Transit-circle Room at the Royal Observatory, Greenwich. By H. H. Turner, M.A., B.Sc.

It has been mentioned in recent Reports of the Council (*Monthly Notices*, vol. xlix. p. 175, vol. l. p. 185, vol. li. p. 208) that experiments were in progress on the distribution of temperature in the transit-circle room at the Royal Observatory, Greenwich. A few observations of this kind were made in 1879 May and June, but the investigation was not carried further when it was found that there was no serious anomaly in the gradual diminution of temperature outwards from the instrument. But for several reasons it has seemed advisable to inquire more closely into the matter.

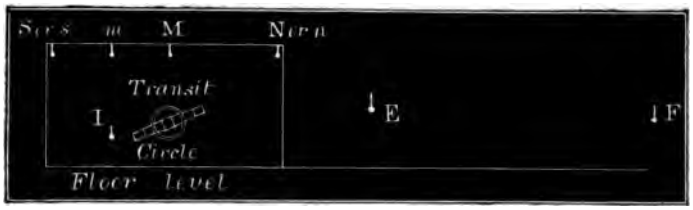
Six thermometers in all were read as nearly simultaneously as practicable, two or three times in the course of the evening, by the transit-circle observer. Three of them are in general use for computing refraction: viz. the interior thermometer (I) placed near the instrument, the exterior thermometer (E), near the north wall of the room, and the Front Court thermometer (F) mounted on a post with a revolving shade to protect it from the Sun, 53 feet from the exterior north wall of the transit-circle room. The other three thermometers were placed in the shutter opening along the horizontal roof of the transit-circle room—one (N) at the north corner, another (M) in the middle, and the third (S) at the south corner. It was soon found that there was a systematic difference between the readings of (N) and (S); that is to say, the distribution of temperature was not symmetrical in the north and south direction. To eliminate any effect of residual index error on this difference the thermometers (N) and (S) were in 1890 January interchanged. At the same time the thermometer (M) was removed from its central position and placed further to the south, directly over the thermometer (I), but still in the shutter opening. In these new positions the thermometers are designated (*n*), (*m*), and (*s*). The following table gives all requisite information as to the identity and position of the six thermometers:—

TABLE I.

Distinguishing Letter.	Number.	Index Correction.	Distance from Centre of Transit Circle. North.	East.	Above.
		°	ft.	ft.	ft.
I	12264	−0·5	− 7·3	+ 2·4	− 0·6
E	45357	−0 2	+23	+ 2·6	+ 1·0
F	44520	−0 3	+71	−36	− 0·5
N	A2637	−0·2	+17·5	+ 0·5	+13
M	A2645	−0·2	0 0	− 0·5	+13
S	A2640	−0·2	−17·5	+ 0·5	+13
n	A2640	−0·2	+17·5	+ 0·5	+13
m	A2645	−0·2	− 7·3	− 0·5	+13
s	A2637	−0·2	−17 5	+ 0·5	+13

The numbers are those assigned by Messrs. Negretti and Zambra, by whom all the thermometers were made. The index corrections are adopted from comparisons with the standard thermometer on 1889 March 15.

The following diagram shows the approximate positions of the thermometers projected on the meridian plane.



It soon became apparent that very anomalous results were obtained if some of the six shutters of the transit-circle room were left closed. The best conditions for observation are undoubtedly when the room has been thrown open to the external air as much as possible for a considerable time; but these conditions are not always attainable in practice. In bad weather the shutters are sometimes thrown open for a few minutes only, to snatch an observation between clouds, or even between showers; and on windy nights it is often necessary, in observing stars by reflexion, to close the shutters behind the observer. Shutters not actually interfering with observations at the time may again be left closed inadvertently; and, generally speaking, there are so many observations made in conditions when the circulation of air has been restricted that a complete investigation should include a determination of the effect of such restrictions. This may be undertaken later, but throughout the period here under discussion the thermometers were directed to be read only when all the shutters had been open for at least 15 minutes, and the actual time elapsed since opening was to be noted.

The observations were collected in groups according to the reading of (F) the front court thermometer (each group extending over 5°), and the following tables exhibit the mean excess of each thermometer over (F), corrected for index error:—

TABLE II.

1888 *April* 1, *to* 1889 *December* 31.

	Mean Reading of F.	No. of Obs.	I	Mean Excess over F of M	N	S	E
	28°3	9	+4°34	+2°92	+1°79	+1°17	+0°62
	32·5	18	+3·36	+1·87	+1·46	+1·14	+0·39
	37·7	36	+3·04	+1·65	+1·03	+1·02	+0·17
	42·5	62	+3·01	+1·40	+1·17	+0·76	+0·07
	47·3	60	+2·72	+1·19	+0·85	+0·67	−0·08
	52·7	68	+2·71	+0·94	+0·88	+0·42	−0·13
	57·4	43	+2·13	+0·74	+0·67	+0·32	−0·06
	62·0	24	+1·38	+0·48	+0·15	−0·10	−0·66
	66·6	5	+1·06	+0·82	+0·64	+0·30	−0·58
Simple Mean	47·4		+2·64	+1·33	+0·96	+0·63	−0·03

TABLE III.

1890 *January* 1, *to* 1891 *March* 31.

	Mean Reading of (F)	No. of Obs.	I	Mean Excess over F of *m*	*n*	*s*	E
	23°8	6	+4°23	+3°62	+2°40	+1°67	+1°10
	27·1	2	+4·45	+2·40	+2·00	+1·25	+0·85
	32·8	13	+3·31	+2·14	+1·52	+0·92	+0·26
	37·2	32	+3·15	+1·74	+1·19	+1·07	+0·31
	43·0	25	+3·25	+1·77	+1·12	+0·87	+0·23
	47·4	34	+3·18	+1·61	+1·03	+0·63	−0·03
	51·9	24	+2·85	+1·05	+0·78	+0·37	+0·11
	56·7	26	+2·55	+0·97	+0·75	+0·38	+0·17
	61·6	8	+2·13	+1·44	+1·11	+0·50	−0·11
Simple Mean	42·4		+3·23	+1·86	+1·32	+0·85	+0·32

Several general features of these tables are somewhat striking. We may first notice the excess of N over S, and *n* over *s*. As above remarked, the index error affects these excesses in opposite directions; and we may use these observations to determine the difference of residual index errors. If this difference be *e*, we have

$$(N-S)-(n-s)=2e$$

The value of *e* deduced from the various groups is exhibited in the following table:—

TABLE IV.

Limits of Reading of F.	N−S.	No. of Obs. = p	$n-s$.	No. of Obs. = q	½ (Diff.) = e	Weight, $= \frac{2pq}{p+q}$.
° °	°		°		°	
20−30	+0·62	9	+0·73	8	−0·06	8
30−35	+0·32	18	+0·60	13	−0·14	15
35−40	+0·01	36	+0·12	32	−0·06	34
40−45	+0·41	62	+0·25	25	+0·08	35
45−50	+0·18	60	+0·40	34	−0·11	43
50−55	+0·46	68	+0·41	24	+0·02	35
55−60	+0·35	43	+0·37	26	−0·01	34
60−70	+0·27	29	+0·61	8	−0·17	13
	Weighted Mean		... ...	...	−0·05	

Since the readings of the thermometers were only estimated to tenths of a degree in the comparison on 1889 March 15, this result may be considered satisfactory; and we may presume that

(1) The index errors of the thermometers are determined to within 0°·1.

(2) The graduation of the thermometers is satisfactory, and correct standard readings are given by the application of a uniform index error as above.

The second noticeable feature of the tables is the nearly uniform decrease of the excesses with the rise of mean temperature. Linear equations were deduced from the observations as follows: the simple means shown at the foot of Tables II. and III. were subtracted from the numbers in the columns above them; and the signs of the results changed when that in column (1) was negative. Thus all the results for column (1), and nearly all those for the other columns, are now positive; and the sum of the members of any column, say E, divided by the sum of column (1) gives the rate of decrease of E−F per degree of F. This process is nearly equivalent to that of least squares and very much less cumbersome, while probably sufficiently accurate for the purpose. The groups are weighted equally instead of as their distance from the mean, but on the other hand no allowance has been made for the fact that the number of observations is smaller for the extreme groups than for the others. The following are the resulting equations:—

From Table II.	*From Table III.*
$I-F=(87\overset{\circ}{\cdot}3-F)\times 0\cdot066$	$I-F=(112\overset{\circ}{\cdot}9-F)\times 0\cdot045$
$M-F=(74\cdot2-F)\times 0\cdot049$	$m-F=(79\cdot6-F)\times 0\cdot050$
$N-F=(78\cdot3-F)\times 0\cdot031$	$n-F=(79\cdot5-F)\times 0\cdot035$
$S-F=(67\cdot3-F)\times 0\cdot031$	$s-F=(69\cdot5-F)\times 0\cdot031$
$E-F=(48\cdot4-F)\times 0\cdot027$	$E-F=(55\cdot4-F)\times 0\cdot024$

and these expressions give the following residuals:—

TABLE V.

Residuals for Table II.

Mean Reading of F.	I	M	N	S	E
28°·3	+0°·44	+0°·64	+0°·24	−0°·06	+0°·13
32·5	−0·26	−0·20	+0·04	+0·04	+0·01
37·7	−0·24	−0·16	−0·23	+0·08	−0·07
42·5	+0·05	−0·17	+0·06	−0·02	−0·03
47·3	+0·07	−0·15	−0·11	+0·04	−0·05
52·7	+0·42	−0·13	+0·08	−0·04	+0·05
57·4	+0·15	−0·09	+0·02	+0·01	+0·24
62·0	−0·29	−0·12	−0·36	−0·27	−0·23
66·6	−0·31	+0·44	+0·28	+0·27	−0·02

TABLE VI.

Residuals for Table III.

Mean Reading of F.	I	*m*	*n*	*s*	E
23°·8	+0°·15	+0°·83	+0°·42	+0°·24	+0°·32
27·1	+0·52	−0·22	+0·14	−0·08	+0·15
32·8	−0·36	−0·20	−0·12	−0·23	−0·30
37·2	−0·32	−0·38	−0·32	+0·06	−0·14
43·0	+0·05	−0·06	−0·20	+0·02	−0·09
47·4	+0·17	0·00	−0·12	−0·07	−0·23
51·9	+0·06	−0·34	−0·20	−0·18	+0·02
56·7	−0·03	−0·18	−0·06	−0·02	+0·20
61·6	−0·22	+0·54	+0·47	+0·25	+0·04

The residuals seem to indicate that, in some cases at least, a curve would suit the observations better than a straight line, more especially those for M and *m*, though here an allowance for large accidental error in the terminal groups, where the observations are not numerous, would do almost equally well. At any rate, straight lines give a very good first approximation.

Considering now the various thermometers in turn, we remark first the discordance between the two results for I. No change was made during the observations which can be assigned as a cause for this difference, which is apparently accidental. The residuals for I are numerically larger than those for all the other thermometers except *m*, as might be expected from the fact that it is nearer disturbing causes—gas jets, and the observer's body, &c. Taking a mean between the two expressions,

viz.: I–F = (100° – F) × ·005, and comparing this with both tables, we get the following residuals:—

TABLE VII.

Limits of Reading of F.	Table II.	Table III.
° °	°	°
20–25	...	+0·04
25–30	+0·39	+0·40
30–35	−0·36	−0·39
35–40	−0·41	−0·31
40–45	−0·16	+0·11
45–50	−0·18	+0·28
50–55	+0·10	+0·20
55–60	−0·22	+0·16
60–65	−0·71	+0·01
65–70	−0·78	...

from which it appears that the discordance is chiefly due to the observations at high temperatures in the summer: for as far as 45° the accordance is striking.

The expressions for M and *m* relate to the same thermometer in different positions; but, curiously enough, though *m* was south of M, and its readings might have been expected (from the marked excess of N over S) to be smaller than those of M, we find them actually larger by the nearly constant quantity 0°·20. On examining the situation of *m*, it was noticed that a metal pipe, which carries off the products of combustion of a gas flame used to illuminate the clock, passes within 3 or 4 feet of *m*, while this and other similar pipes do not pass near any of the other thermometers; and it is probably the influence of this heated pipe which raises the temperature at *m* some half a degree above that which we should expect by interpolation between M and S.

The expressions for N and *n* and for S and *s* are satisfactorily accordant; while in the case of E we encounter a discordance similar to that for I, though less conspicuous in amount: viz. the factor for E from Table III. is smaller, while the reading of F at which I–F vanishes is larger than for Table II. Something would therefore seem to have affected E and I differently in the two series of observations, leaving N and S undisturbed (about M, whose position was changed, we can say nothing). The accordance of N with *n* and S with *s* is also significant as showing that the readings of F in the two series are comparable. The thermometers were all referred to F because the conditions of its exposure most nearly approach standard conditions. Some slight changes were, however, made in the exposure of F during the observations. In 1888 July a transit hut for longitude observations was erected near F to the east; and in 1888 Septem-

ber another hut to the N.-W. of the post carrying F. The latter hut was removed in 1889 August, but the former remained throughout, and on 1890 February 28 the post carrying the thermometer F was dug up and removed to a greater distance from this hut, the neighbourhood of which might, it was feared, be influencing the exposure of F. But this does not seem to have been the case. We must look to some accidental feature of the weather for the changes in I and E, or, perhaps, to the fact that Table II. is based on observations in two summers and a winter, Table III. on two winters and a summer. The discussion which follows, of the effect of the seasons on the thermometers, will elucidate this point.

Before passing, however, to this discussion it is to be remarked that there is a physical significance for the constants in the linear equations on p. 427, and especially for the constant within the brackets. It is the standard external temperature at which the point of suspension of any thermometer is sensibly at the temperature of the external air. If we regard any thermometer as being disturbed by a single source of heat, this temperature should be that of the disturbing source. There are, of course, several such disturbing sources, viz., gas flames, the observer's body, and the walls of the room; and the significance of the constant within brackets is thus somewhat complex. But it is satisfactorily in accordance with this interpretation that the value of the constant should be large for I and small for E; for I is presumably disturbed by sources of high temperature, such as gas flames, while E is disturbed by sources of low temperature, probably the external walls of the building. Since the sub-permanent temperature of these walls must be different in winter and summer, the discussion of the seasonal effect will throw more light on this point.

If the mean of the readings in each calendar month be taken we get the following results :—

TABLE VIII.

1888.	Mean Excess over F of					Mean Reading of F
	I	M	N	S	E	
Apr.	+2·84	+1·83	+1·60	+0·85	+0·35	42·4
May	+2·79	+1·22	+0·80	+0·55	+0·11	49·4
June	+2·35	+0·58	+0·85	+0·24	+0·13	55·3
July	+2·35	+0·85	+1·05	+0·46	+0·08	54·4
Aug.	+2·34	+1·21	+0·78	+0·47	−0·54	57·4
Sept.	+2·75	+0·96	+0·90	+0·86	−0·33	52·2
Oct.	+2·12	+0·80	+0·64	+0·30	−0·50	46·7
Nov.	+2·73	+1·03	+0·87	+0·70	0·00	44·0
Dec.	+2·87	+1·37	+1·00	+1·07	−0·05	40·9

1889.	I	Mean Excess over F of M	N	S	E	Mean Reading of F
Jan.	+1·96	+0·98	+0·63	+0·73	+0·23	36·9
Feb.	+2·01	+0·85	+0·77	+0·52	+0·56	36·6
Mar.	+2·76	+1·47	+0·92	+0·81	−0·02	38·6
Apr.	+2·90	+1·40	+1·02	+0·61	−0·15	43·3
May	+2·59	+1·08	+0·60	+0·28	−0·57	52·1
June	+1·79	+0·66	+0·39	−0·14	−0·60	57·9
July	+2·70	+0·96	+0·42	+0·15	−0·23	58·7
Aug.	+2·93	+1·05	+1·05	+0·24	−0·32	57·4
Sept.	+2·72	+1·42	+0·50	+0·76	−0·14	53·4
Oct.	+2·73	+0·98	+0·80	+0·29	−0·24	45·0
Nov.	+4·41	+2·04	+1·72	+1·27	+0·05	36·5
Dec.	+3·32	+1·74	+1·18	+1·33	+0·33	33·2
1890.						
Jan.	+2·31	+0·95	+0·59	+0·63	+0·09	42·1
Feb.	+2·69	+1·26	+0·84	+0·51	+0·11	36·2
Mar.	+2·90	+2·00	+1·34	+1·45	+0·20	40·9
Apr.	+3·72	+2·12	+1·41	+1·00	+0·47	40·2
May	+3·45	+1·67	+0·97	+0·61	+0·18	49·6
June	+3·44	+1·17	+0·81	+0·22	+0·09	54·7
July	+2·88	+1·17	+0·87	+0·66	+0·31	56·0
Aug.	+2·95	+1·23	+0·92	+0·53	+0·01	56·7
Sept.	+2·91	+1·61	+1·19	+0·45	+0·18	56·1
Oct.	+3·30	+1·46	+1·11	+0·51	−0·13	44·5
Nov.	+2·96	+1·86	+1·10	+0·95	−0·02	40·8
Dec.	+3·35	+3·40	+1·85	+1·15	+0·65	28·3
1891.						
Jan.	+2·91	+1·81	+1·57	+0·96	+0·47	33·1
Feb.	+3·67	+2·77	+1·83	+1·40	+0·60	37·0
Mar.	+4·00	+1·10	+1·20	+0·50	+0·70	41·8

Taking the months of the same name together, and weighting according to the number of observations, we get the following results for the annual inequality, where the time of year, and not the actual temperature, is now taken as the independent variable :—

TABLE IX.

	Mean Excess over F of					Mean Reading of F
	I	M	N	S	E	
	°	°	°	°	°	°
Jan.	+2·35	+1·23	+0·91	+0·77	+0·27	37·2
Feb.	+2·51	+1·27	+0·91	+0·41	+0·35	36·4
Mar.	+2·57	+1·77	+1·18	+1·17	+0·13	40·1
Apr.	+3·09	+1·76	+1·37	+0·81	+0·23	43·9
May	+2·93	+1·38	+0·80	+0·59	−0·02	50·1
June	+2·48	+0·78	+0·68	+0·10	−0·13	56·0
July	+2·60	+0·97	+0·82	+0·43	+0·06	56·1
Aug.	+2·67	+1·16	+0·90	+0·41	−0·33	57·2
Sept.	+2·79	+1·35	+0·85	+0·67	−0·11	53·8
Oct.	+2·73	+1·09	+0·86	+0·38	−0·28	45·4
Nov.	+3·32	+1·58	+1·17	+0·93	+0·07	40·9
Dec.	+2·97	+1·59	+1·09	+1·14	+0·13	36·0

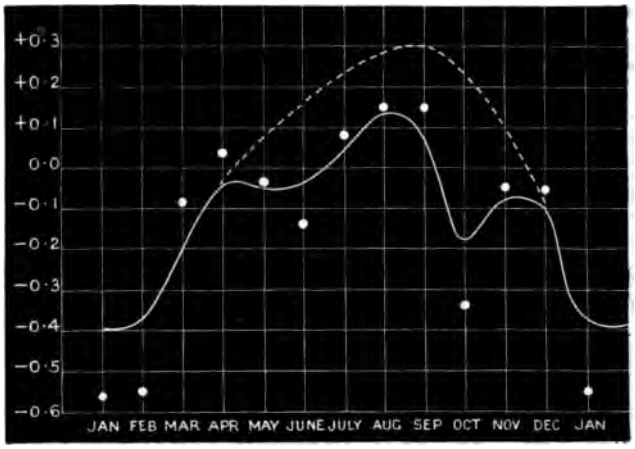
The effect of the transformation is remarkable. The mean standard external temperature in the last column shows an annual inequality with a range of some 20°, but the interior thermometers do not respond to this as we might have expected from the previous discussion.

The following table shows the mean monthly excess of these quantities over the theoretical expressions on p. 13, the two series having been combined with proper weights:—

	I	M	N	S	E	Mean
	°	°	°	°	°	°
Jan.	−1·07	−0·88	−0·56	−0·25	−0·12	−0·58
Feb.	−0·90	−0·91	−0·56	−0·45	0·00	−0·56
Mar.	−0·27	−0·04	−0·21	+0·18	−0·13	−0·09
Apr.	+0·13	+0·01	+0·09	−0·02	+0·01	+0·04
May	+0·39	−0·13	−0·19	−0·10	−0·10	−0·03
June	+0·07	−0·36	−0·11	−0·30	+0·01	−0·14
July	+0·44	−0·07	−0·02	−0·06	+0·17	+0·09
Aug.	+0·59	+0·13	+0·16	−0·05	−0·12	+0·14
Sept.	+0·43	+0·14	+0·00	+0·22	−0·02	+0·15
Oct.	−0·13	−0·53	+0·29	−0·36	−0·33	−0·33
Nov.	+0·22	−0·20	−0·07	+0·09	−0·17	−0·03
Dec.	−0·30	+0·01	−0·17	+0·11	−0·02	−0·07

Now, a simple annual wave will not adequately represent any of these curves. There are two well-marked dips in May and October, giving the wave the appearance of being "squashed" in the middle by a secondary cause, as indicated by the continuous wave suggested by a dotted line in the diagram. I

venture to interpret this wave as follows:—If an interior thermometer were disturbed by sources of heat *of constant temperature* alone, such as the observer's body and the gas flames, its excess over the standard thermometer would probably be simply a function of the external temperature. Consider, for



instance, the observer's body alone. When the external temperature was that of the body, both thermometers should agree; but the colder the weather the larger would be the influence of the body in raising the reading of the interior thermometer.

But the disturbance arising from the walls of the room is different. Their sub-permanent temperature is higher in summer than in winter, and hence, on a day in summer, when the external temperature was (say) 45°, they would raise the interior thermometer more than on a day in winter when the external temperature was also 45°. Thus an expression for the reading of an interior thermometer as a function of external temperature alone is not sufficient. We must add a term following the temperature of the walls of the room. And it seems to me that the "squashing" of the above curve affords evidence that the influence of the walls is a *vera causa*. I ascribe this break of continuity to the fact that fires are lit in the adjoining buildings during the winter months, but not used from about May to October. If they were retained the sub-permanent temperature of the walls would make a simple sweep of annual period, but the rise is checked by losing the fires, as is the fall by recovering them. This is, however, at present, mere conjecture.

The fact remains that the readings of the interior thermometers are functions of the external temperature and of the time of year combined. This is exhibited more directly in the following tables of double entry:—

Month.	20° to 25°	25° to 30°	30° to 35°	35° to 40°	40° to 45°	45° to 50°	50° to 55°	55° to 60°	60° to 65°	65° to 70°
					Excess of Thermometer I over F.					
Jan.	+4·2	+3·2	+3·3	+2·4	+2·2	+0·8	−0·2	...	...	...
Feb.	...	+3·2	+3·5	+2·6	+1·7	+0·7	...	...	...	...
Mar.	+4·6	+5·3	+2·1	+2·7	+3·1	+1·4	+1·5	...	...	...
Apr.	...	+5 6	+4·1	+4·1	+3·4	+2·2	+0·8	...	...	...
May	...	...	...	+4·7	+4·3	+3·7	+2 9	+2·0	+1·2	...
June	...	...	...	...	...	+3·8	+3·2	+2·4	+2·1	+0·9
July	...	...	...	...	...	+5·3	+3·0	+2·9	+1·8	...
Aug.	...	...	...	...	...	+4·4	+3·7	+3 2	+1·4	+1·8
Sept.	...	...	...	+6 2	+4·8	+3·7	+3·0	+2·4	+2·9	−0·1
Oct.	...	...	+4·5	+3·5	+3·2	+2·9	+2·5	+0·7	...	...
Nov.	+4·0	+6·1	+4·9	+4·1	+3 0	+2·5	+1·1	...	...	...
Dec.	+5·1	+4·5	+3·2	+3·0	+3·5	+2·7	+1·1	...	...	...
					Excess of Thermometer E over F.					
Jan.	+0·9	+0·6	+0·2	+0·2	0·0	−0·3	−0·5	...	...	...
Feb.	...	+0·8	+0·3	+0·2	+0·1	−0·1	...	...	...	...
Mar.	+1·1	−0·8	+0·6	−0 2	0·0	0·0	−0·4	...	...	...
Apr.	...	+0·9	+0·7	+0·5	+0·1	−0·2	−0·5	...	...	...
May	...	...	...	−0·3	+0·3	0·0	−0·1	0·0	−0·5	...
June	...	...	...	...	...	−0·1	−0·2	−0·3	−0·4	+0·2
July	...	...	...	...	...	+1·1	0·0	+0·2	−0·2	...
Aug.	...	...	...	...	...	−0·3	−0·1	−0·2	−1 0	−1·0
Sept.	...	...	...	−0·2	+0·2	−0·4	−0·2	+0·1	−0·3	−0·7
Oct.	...	...	+0·2	−0·5	−0·6	−0·2	−0·2	−0·6	...	...
Nov.	+0·6	+0·9	0 0	+0·3	+0·1	−0·4	−0·6	...	...	...
Dec.	+1·4	+0·5	−0·2	+0·1	+0·1	−0·4	−0·7	...	...	...
					Excess of Thermometer N over F.					
Jan.	+2·0	+2·5	+1·1	+0·7	+0·4	+0·2	−0·4	...	...	...
Feb.	...	+1·0	+1·4	+0·7	+0·2	+0·2	...	...	...	...
Mar.	+3·1	+1·5	+0·9	+0 9	+1·0	+0 3	+0·2	...	...	...
Apr.	...	+2·9	+2·2	+1·5	+1·0	+0 7	+0·3	...	...	...
May	...	...	...	+1·1	+1·4	+0·9	+0·7	+0·4	+0·2	...
June	...	...	...	...	...	+0·6	+0 9	+0·5	+0·1	+0·5
July	...	...	...	...	...	+1·5	+1·0	+0·8	+0·3	...
Aug.	...	...	...	...	...	+1·6	+1·1	+1·0	0·0	+0·9
Sept.	...	...	...	+1 6	+1·3	+1·3	+0·6	+0·5	+1·5	−0 5
Oct.	...	...	+2·6	+0·6	+0·9	+0·8	+0·3	+0 1	...	...
Nov.	+0·8	+1·3	+1 9	+1·4	+1·0	+0·6	0·0	...	...	...
Dec.	+3·0	+1·5	+0·9	+1·1	+1·3	+0·4	−0·1	...	...	...

Month.	20° to 25°	25° to 30°	30° to 35°	35° to 40°	40° to 45°	45° to 50°	50° to 55°	55° to 60°	60° to 65°	65° to 70°
					Excess of Thermometer M over F.					
Jan.	+3·0	+1·7	+1·5	+0·9	+0·7	+0·5	0·0	...	...	...
Feb.	...	+1·1	+1·9	+1·0	+0·4	+0·3	...	...	...	...
Mar.	+4·3	+2·9	+1·0	+1·3	+1·5	+0·5	+0·6	...	...	...
Apr.	...	+4·3	+2·8	+2·3	+1·4	+1·1	+0·1	...	...	...
May	...	...	...	+2·2	+2·2	+1·5	+0·9	+0·6	+0·8	...
June	...	...	...	...	...	+1·5	+0·7	+0·5	+0·5	+0·3
July	...	...	...	...	...	+2·6	+1·0	+0·8	+0·4	...
Aug.	...	...	...	...	...	+1·7	+1·5	+1·3	+0·2	+1·1
Sept.	...	...	...	+5·4	+1·0	+1·7	+0·7	+0·7	+2·1	+0·1
Oct.	...	...	+2·2	+1·5	+0·9	+1·0	+0·5	+0·2	...	...
Nov.	+1·7	+2·9	+1·9	+2·1	+1·6	+0·7	+0·5	...	...	...
Dec.	+4·9	+3·0	+1·9	+1·3	+1·4	+0·7	+0·2	...	...	...
					Excess of Thermometer S over F.					
Jan.	+1·0	+0·7	+1·0	+0·6	+0·5	+0·3	−0·1	...	...	...
Feb.	...	+0·5	+0·7	+0·5	+0·1	+0·1	...	...	...	...
Mar.	+2·7	+0·1	+0·9	+0·7	+0·8	+0·8	+0·6	...	...	...
Apr.	...	+2·3	+1·2	+1·0	+0·6	+0·4	−0·1	...	...	...
May	...	...	...	+0·4	+1·1	+0·6	+0·2	+0·1	+1·0	...
June	...	...	...	...	...	+0·1	+0·2	0·0	−0·5	−0·2
July	...	...	...	...	...	+2·1	+0·5	+0·3	−0·2	...
Aug.	...	...	...	...	...	+1·1	+0·6	+0·6	+0·5	+0·5
Sept.	...	...	...	+3·0	+1·0	+0·9	+0·5	+0·2	+0·6	−0·3
Oct.	...	...	+0·5	+0·1	+0·1	+0·5	0·0	+0·2	...	...
Nov.	+0·6	+1·6	+1·7	+1·0	+0·9	+0·4	+0·4	...	...	...
Dec.	+1·4	+1·0	+0·8	+1·4	+1·5	+0·6	+0·3	...	...	...

The effect of the seasons is best seen in the column 45° to 50° common to all the months. The gradual diminution with rise of temperature is seen in any horizontal row.

This paper was already in type when Mr. Ellis suggested to me a concise method of dealing with these tables. He remarked that the reading of any thermometer appeared to be approximately a function of the *difference of the external temperature from the average*. The excess of any thermometer is, for instance, about the same in January for temperatures of 28°, 38°, and 48° as in July for temperatures of 50°, 60°, and 70°; the average temperature in January for the period under consideration being 38°·3, and in July 59°·5. I therefore analysed the tables afresh from this point of view. I was at first in doubt whether to select the average temperature for the approximate hour of observation (say, 9 P.M.) or the general average throughout the day as the basis; but a few figures show at once that

this point is not important. The two systems of averages for the period in question are shown in the following table:—

Month.	General Average.	Average at 9 P.M.	Month.	General Average.	Average at 9 P.M.
Jan.	38°·3	38°·4	July	59°·5	57°·6
Feb.	37·8	37·4	Aug.	59·6	57·2
Mar.	41·4	40·4	Sept.	57·1	54·8
Apr.	44·9	43·1	Oct.	48·1	46·7
May	54·7	52·0	Nov.	45·1	44·4
June	59·3	57·2	Dec.	36·1	35·7

The greatest difference between the two systems is 2°·7 in May, corresponding to a difference of about 0°·3 in the excess I—F. It is, therefore, almost immaterial which system we select; but as the influence of the walls (whose temperature would be more nearly related to the general average than to the average at a particular hour) has been suggested, it seems preferable to take the general average as our basis.

Assuming, then, that the excess of any thermometer over F may be represented by the expression

$$a - b \text{ (excess of F above average)},$$

I find the following approximate values for a and b:—

	I—F		N—F		M—F		S—F		E—F	
	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
Jan.	2°·1	0·13	0°8	·09	1°·1	·08	0°·5	·07	+0°·1	·04
Feb.	2·3	·14	0·7	·07	0·9	·08	·4	·03	+0·3	·03
Mar.	2·6	·10	0·8	·07	1·3	·09	·8	·03	−0·1	·92
Apr.	2·6	·16	0·9	·10	1·3	·15	·5	·08	−0·1	·06
May	2·3	·15	0·4	·05	0·7	·10	·5	·02	−0·2	·01
June	2·2	·13	0·4	·03	0·6	·05	−·1	·03	−0·1	·00
July	2·5	·18	0·5	·07	0·6	·12	·0	·13	0 0	·06
Aug.	2·6	·16	0·8	·06	0·8	·06	·6	·02	−0·6	·05
Sept.	2·5	·14	0·5	·05	1·2	·09	·5	·07	−0·3	·01
Oct.	2·6	·11	0·7	·07	0 9	·06	·2	·00	−0 3	·00
Nov.	2·6	·14	0 7	·04	1·1	·06	·6	·04	−0·2	·04
Dec.	3·4	·09	1·2	·06	2·0	·12	1·0	·01	+0 2	·05

There is obviously a very fair accordance between these numbers. If we divide the year into two periods of six months, November—April and May—October, the mean values of the above quantities are—

	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)	(*a*)	(*b*)
Winter	2°·6	·13	0°·8	·07	1°·4	·10	0°·6	·04	0°0	·04
Summer	2 5	·15	0·6	·06	0 8	·08	0·3	·05	−0·3	·02

Now, according to the views already expressed in this paper, we may regard the constant (a) in each case as resulting from disturbance by the gas-flames and the observer's body. When the temperature is just the average the walls will be nearly at the temperature of the external air, and but for the gas-flames and the observer's body the interior of the room should be so too; but these disturbing causes raise the temperature of any given point in the room by a nearly constant quantity throughout the year. The quantity is a little greater in winter than in summer, as we should naturally expect; close to the instrument (thermometer I) it is about 0°·1 greater in winter out of 2°·5; at the boundary of the shutter opening (thermometers N, M, S) it is about 0°·9 in winter and 0°·6 in summer. The difference between winter and summer is 0°·3 also for thermometer E; but it is not easy to explain the negative value for E, which is, however, possibly accidental.

The term with coefficient (b) is to be considered as due to the walls, which tend to lower the internal temperature when the external is above the average, and to raise it when the external is below. Close to the instrument (thermometer I) the influence of the walls annuls that of the gas-flames when the external temperature is about 16° above the average, and doubles it when about 16° below. In the shutter opening (thermometers N, M, S) the annulling is effected at 11° above, and the doubling at 11° below. We are thus led to the following important conclusion:—

A phenomenon which depends purely upon the distribution of temperature inside the transit-circle room should disappear when the external temperature is about 13° *above the average, and be doubled when the temperature is about* 13° *below the average.*

Two minor points have been investigated—(A) the change in reading as the shutters have been left open for a longer time; and (B) the influence of the direction of the wind.

(A) As stated above, it was directed that the thermometers should be read only when the shutters had been thrown open at least fifteen minutes; and the time since opening was to be recorded. The results were arranged according to these recorded times, and means taken, as in the following table:—

	Time since Shutters were Opened.							
Excess over Theoretical Value of	½ hr. or less	½ hr. to 1 hr.	1 hr. to 1½ hr.	1½ hr. to 2 hrs.	2 hrs. to 3 hrs.	3 hrs. to 4 hrs.	4 hrs. to 5 hrs.	More than 5 hrs.
	°	°	°	°	°	°	°	°
I−F	−1·27	−0·18	−0·14	+0·09	+0·02	−0·02	+0·10	+0·56
N−F	−0·62	0·00	+0·01	−0·09	−0·03	+0·39	+0·19	+0·19
N−F	−0·67	−0·09	−0·22	−0·03	0·00	+0·66	+0·28	+0·51
S−F	−0·17	−0·15	−0·21	−0·01	−0·16	+0·20	+0·01	+0·55
E−F	−0·06	−0·04	−0·14	+0·05	+0·08	−0·10	+0·02	+0·01
Mean	−0·56	−0·09	−0·16	0·00	−0·02	+0·23	+0·12	+0·36

The general result is, that although a slow change goes on for a considerable time in the distribution of temperature in the room, it is comparatively rapid for the first hour. But it is remarkable that this change should be a *rise* of temperature—*i.e.* when shutters are closed the room is below the normal temperature! The explanation is doubtless to be found in the fact that when the observer opens the shutters he also turns up various gas jets.

If the results are analysed according to the excess or defect of temperature from the average, it is found that the rise of internal temperature is much more rapid when the external temperature is *above* the average.

(B) The observations were divided into eight groups, according to the direction of the wind as recorded in the Meteorological Department, the eight major points N., N.E, E., S.E., S, &c. being selected as a sufficiently close approximation. There is, of course, much more S.W. wind than any other. The results are shown in the following table:—

Excess above Theoretical Value of	Direction of Wind. N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
	°	°	°	°	°	°	°	°
I−F	+0·38	+0·50	+0·23	+0·10	−0·15	−0·32	−0·41	−0·26
N−F	+0·54	+0·01	−0·16	−0·27	+0·06	−0·04	−0·09	+0·02
M−F	+0·53	+0·44	+0·34	+0·01	−0·14	−0·32	−0·43	+0·01
S−F	+0·49	−0·08	+0·08	−0·37	−0·29	−0·10	−0·18	+0·19
E−F	+0·45	+0·15	+0·01	−0·30	−0·23	−0·17	−0·04	+0·63
Mean	+0·48	+0·20	+0·10	−0·17	−0·15	−0·19	−0·23	+0·12

The general result is, that the interior temperature is higher with easterly winds than with westerly.

General Conclusions.

The distribution of temperature in the transit-circle room must have a sensible influence on zenith-distance observations. It is not, however, proposed to consider the manner of this disturbance here; it is deemed advisable to limit the scope of this paper to a statement of the results obtained by the reading of six thermometers placed at different points of the room during three years, on nights when astronomical observations were possible. The general conclusions are as follows:—

(1) The excess of interior temperature over exterior is larger in cold weather than in warm a linear relation between this excess and the external temperature is a fair approximation for a thermometer hung at any point of the room.

(2) This linear relation is disturbed by the seasons. In all months of the year an external temperature of (say) 45° is liable

to occur in the evening; but the readings of an interior thermometer would be higher in summer than in winter on such an evening.

(3) This is possibly due to the influence of the walls of the room, whose sub-permanent temperature is higher in summer than in winter. Circumstantial evidence of this influence is perhaps afforded by a break of continuity when fires are lighted or given up in the adjacent buildings.

(4) Regarding the matter from another point of view, the internal temperature depends simply upon the difference of external temperature from the average.

(5) When the shutters of the room are thrown open a readjustment of temperature proceeds somewhat rapidly for about an hour, and also afterwards, but more slowly. But it is a *rise* of temperature, and is probably due to the turning up of the gas simultaneously with the opening of the shutters.

(6) The interior temperature is generally higher with easterly winds than with westerly.

The Orbit of τ Cygni. By S. W. Burnham, M.A.

The companion to this star was discovered by Alvan G. Clark in 1874, October, with the 26-inch object glass, which was subsequently mounted at the McCormick Observatory. At this time the new pair was not difficult, and it was measured on many nights in the few years following by Dembowski with an instrument of about seven inches aperture. His observations were the first to show that the small star was in motion, and they continued long enough to prove a change of about 30° in angle, with some diminution of the distance. It was soon evident that this was orbital motion. The large star was known to have a large proper motion, amounting annually to 0″·484 in the direction of 17°·3, and the measures showed that this belonged to the small star as well, and that they must form a physical system. The companion was also measured by other observers from time to time, but very little was done for some years following 1880. It had become a much closer and more difficult object, and like all similar pairs it was neglected by many observers with instruments sufficiently powerful to measure it properly.

When my work in this line commenced at the Lick Observatory, I placed this pair on the working list, and observed it regularly every year as long as I remained there. By this time the change in distance of the components had made it a rather difficult pair with the 36-inch, except under very favourable conditions.

Gore in 1886, using the measures down to 1885, computed a provisional orbit of this pair, and found a period of 53·87 years (A. N. 2749). Some of the measures were discordant, and the

arc was too small to give any very good result. The apparent orbit found at that time is shown in Fig. 1, and all the measures as used in the computation are accurately laid down to scale. It will be observed that the distance errors are very large, and that almost any ellipse would represent the positions equally well. In fact, a straight line will do this as a whole better than anything else. When the later measures at Mount Hamilton were made, it was clear that the apparent orbit must be represented by a very different ellipse, and therefore special attention was given to measuring the companion with all possible care. The arc passed over is now nearly 180°, and with a sufficient number of reliable measures a good orbit should be made. The following are all the published measures of this pair, arranged in chronological order:—

1874·89	162°·6	1″·11	2*n*	Newcomb
1875·12	174·5	1·24	2*n*	Dembowski
1875·69	170·5	1·32	3*n*	Dembowski
1876·79	161·5	1·24	2*n*	Dembowski
1876·83	166·9	1·62	2*n*	Waldo
1876·90	160·2	1·03	2*n*	Hall
1877·70	155·3	1·26	8*n*	Dembowski
1878·41	150·0	1·06	1*n*	Burnham
1878·54	147·5	1·09	3*n*	Dembowski
1878·76	158·8	1·09	2*n*	Hall
1879·50	148·3	0·90	2*n*	Burnham
1879·75	147·3	0·98	6*n*	Hall
1880·77	137·4	1·04	1*n*	Frisby
1883·88	159·2	...	3*n*	Seabroke
1885·52	116·3	1·08	3*n*	Tarrant
1885·73	100·7	0·62	1*n*	Hall
1886·78	80· ±	0·5 ±	1*n*	Hough
1887·76	56·4	0·4 ±	1*n*	Hough
1889·49	36·5	0·50	4*n*	Burnham
1890·54	20·5	0·54	3*n*	Burnham
1891·49	12·4	0·61	3*n*	Burnham
1891·69	9·3	0·52	3*n*	Hall
1892·40	2·3	0·61	3*n*	Burnham

It is obvious that some of these measures are of no value in an investigation of the relative motion, and that if any trustworthy conclusion is reached, it must be by rejecting doubtful and incomplete measures, and combining those made on a proper number of nights and by the most experienced observers. There-

fore, as a preliminary step to laying down the positions to scale, I have selected the following:—

1875·46	172°·1	1″·29	5*n*	De.
1876·85	160·8	1·14	4*n*	De.–Hl.
1877·70	155·3	1·26	8*n*	De.
1878 57	152·1	1·08	6*n*	De.–Hl.–*β*
1879·62	147 8	0·94	8*n*	Hl.–*β*
1880·77	137·4	1·04	1*n*	F.
1885·73	100·7	0 62	1*n*	Hl.
1889·49	36·5	0·50	4*n*	*β*
1890·54	20·5	0·54	3*n*	*β*
1891·59	10·8	0·56	6*n*	Hl.–*β*
1892·40	2·3	0·61	3*n*	*β*

These observations are shown on Fig. 2, which is a photographic reduction of the large drawing, by the white circles connected by radial lines with the central star. An examination of these positions shows that the angular motion from 1875 to 1880 is too rapid when compared with the observed places 1889 to 1892; or the motion for the latter interval should be increased to make the areas described proportional to the times. The measures in the first interval are by the most experienced observers with the micrometer, and they are means of a sufficient number of nights to give presumably good results both in angle and distance. The last series of measures were made with the best telescope for the purpose in the world. I used every precaution to get good measures. They were made with a power of at least 1500, with favourable atmospheric conditions, and are consistent with each other. If we assume that the errors are uniformly distributed, which in cases of this kind is certainly not likely to be the fact, and that the angular motion and the distances are too large for the first interval, and correspondingly too small in the second, we find that the apparent ellipse which will satisfy the times requires corrections to the measures which are apparently inadmissible, and that it is necessary to wait for further measures in order to determine where the truth is.

There always remains in an example like this, where observations have some inconsistency when considered together, another method of treating them, which might be termed the heroic treatment, by the introduction of another star which shall account for and explain the apparent anomalies. It is always easy to do this, since one is not hampered by any restrictions, and can assume anything to supply the apparent deficiency shown by the actual observations.

It is obvious from an inspection of the observed positions shown on the diagram what the general character of the supposed

invisible star must be to harmonise the observations. Let us assume that the Clark companion is attended by a "dark" sun of equal mass, the two revolving about the common centre of gravity in an orbit whose plane is at right angles to the line of sight. For the revolution of these stars we may take 17·6 years, since this will answer the purpose as well as any other, and further assume that their apparent distance is a quarter of a second, the position angle of the invisible star being zero at the date of the first measures, and the motion retrograde. Then for the dates of the respective measures the angles are as follows:—

1875·46	P = 360°·0	1885·73	P = 150°·0
1876·85	331·6	1889·49	73·1
1877·70	314·1	1890·54	51·6
1878·57	296·4	1891·59	30·2
1879·62	274·9	1892·40	13·6
1880·77	251·4		

The positions of the dark star at the several dates are indicated on the diagram by dark circles connected by straight lines with the observed positions of the real star. These are omitted for the observations between 1875 and 1880 to avoid confusing the diagram. The distance between the two stars is 0″·25, and of course the centre of gravity is at the middle of the line joining the two circles.

The next step was to draw an ellipse as accurately as possible through the centre of gravity at the various epochs, and after several trials the ellipse shown in the diagram, Fig. 2, was made. When this was examined, and the areas described by the line drawn from the principal star to the centre of gravity of B and C compared with the corresponding times, a very satisfactory agreement was found. The following are the errors of the angles and distances:—

1875·46	0°·0	−0″·07	1885·73	−8°·0	0″·00
1876·85	+2·5	+0·08	1889·49	−2·7	0·00
1877·70	+2·3	−0·06	1890·54	−1·1	−0·01
1878·57	−0·4	+0·10	1891·59	+3·0	0·00
1879·62	−4·0	+0·18	1892·40	−3·1	−0·03
1880·77	0·0	0·00			

Doubtless these errors could have been differently and possibly better distributed, but the variations are small, and will compare favourably with those of most of the computed orbits where the measures are easily made. This harmonises all the measures in angle and distance, and whatever the probabilities may be as to the existence of a disturbing third body, they are at least as strong in this case as in any other instance where a

similar assumption has been made. This ellipse also represents the observed positions of the known companion, leaving the third star out of the question, as well as any which can be drawn at this time, but it will be seen that the errors of the measures are very much larger in angle and distance, and certainly larger than they should be in first-class observations.

The following elements of the orbit are found from this ellipse :—

$$P = 36{\cdot}5 \text{ years}$$
$$T = 1893{\cdot}1$$
$$e = 0{\cdot}24$$

An ephemeris for the visible companion star is easily made from the apparent orbit. The following are the angles and distances of the companion, according to this theory, as they should appear from the measures at these times :—

1893·40	350°0	0″62
1894·40	341·6	0·64
1895·40	332·3	0·64

Before treating this matter very seriously, I would suggest the propriety of waiting until additional observations are made. It may be that the third star can be dispensed with. In any case this pair should be carefully observed each year. A few good measures will be of more value than any amount of speculation. It is evident that the companion can be measured in every part of the orbit. In double star matters we can afford to wait longer for theories than for results with the micrometer. Nor will it do to place too much reliance upon residuals, and the apparent agreement of observations with a proposed theory, since it must be a very poor theory which will not accurately fit the known facts it was intended to explain. It is the subsequent observations which are dangerous to a preconceived theory.

Chicago :
April 20.

Photograph of the Cluster M. 35 Geminorum.

By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 35 *Geminorum*, R.A. $6^h\ 2^m$, Decl. 24°·21′ north, was taken on the 7th February, 1893, with exposure of the plate during 66 minutes. It is No. 1360 in the *General Catalogue*, and is described by Sir J. Herschel as very large; considerably rich; pretty compressed; stars 9th to 16th mag., about 100 stars in one field.

Lord Rosse in his *Observations of Nebulæ and Clusters of Stars*, p. 52, describes the cluster as magnificent, in a rich field, and he estimated 300 stars in the Finder-field of 26 minutes of arc, many of which are not below 11th mag.

On the photograph, now presented, I counted 620 stars in the cluster, within a circle of 26 minutes of arc, in diameter, many of which have close faint apparent *comites*, and some are triple stars. The stars in the region around the cluster are numerous and mostly faint.

The cluster H VI. 17, *General Catalogue*, No. 1351, is shown on the photograph at 1m. 24s. R.A. and 0°·14′·5 Decl. s.p. the cluster M. 35. It is described by Sir J. Herschel as pretty small; much compressed; very rich; irregular triangle of stars extremely small, which description agrees well with the photograph.

Photograph of the Cluster M. 36 Aurigæ.
By Isaac Roberts, D.Sc., F.R.S.

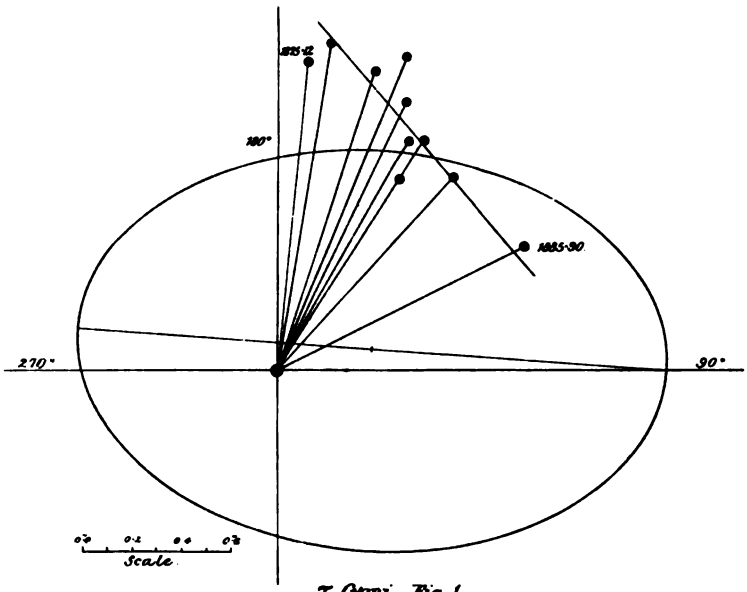
The photograph of the cluster M. 36 *Aurigæ*, R.A. $5^h\ 27^m$, Decl. 34°·6′ north was taken on the 8th February, 1893, with exposure of the plate during 90 minutes. It is No. 1166 in the *General Catalogue*, and is described by Sir J. Herschel as bright, very large; very rich; little compressed; stars 9th to 11th mag. and scattered.

Lord Rosse in his *Observations of Nebulæ and Clusters of Stars*, p. 48, describes it as a coarse cluster of large stars; fine double star in it.

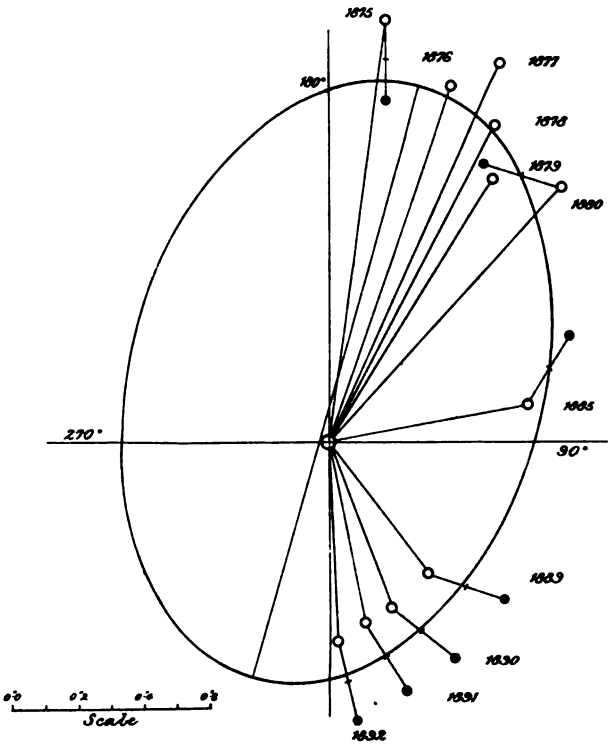
The photograph now presented and enlarged to the scale of 24 seconds of arc to one millimetre agrees generally with the descriptions cited, but there are some stars in the cluster apparently double, and triple; there is also at least one multiple star. There is no nebulosity in the cluster, and the stars are shown to about the 16th mag. This region of the sky is richly covered with stars which by their configurations will in the future afford the astronomer an important field for correlation and study by aid of photographic methods.

Photograph of the Cluster M. 37 Aurigæ.
By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 37 *Aurigæ*, R.A. $5^h\ 45^m$. Decl. 32°·31′ north was taken on the 8th February, 1893, with exposure of the plate during 90 minutes. It is No. 1295 in the *General Catalogue*, and is described by Sir J. Herschel as rich; pretty compressed in the middle; stars large and small.



τ. Cygni. Fig. 1



woods & Co. Lith. London.

τ Cygni. Fig. 2.

Lord Rosse in his *Observations of Nebulæ and Clusters of Stars* calls attention to wonderful loops and curved lines of stars.

By the photograph now presented and enlarged to the scale of 24 seconds of arc to one millimetre, the descriptions cited are confirmed, and some of the stars in the cluster appear to be double, triple, and multiple, and the region around is much crowded with stars, each one of which is now shown, to a scale, in true relative position and magnitude down to about the 16th. The configurations of the stars are, in the words of Lord Rosse, wonderful.

Photograph of the Cluster M. 50 Monocerotis.
By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster M. 50 *Monocerotis*, R.A. $6^h\ 58^m$, Decl. $8°{\cdot}11'$ south was taken on the 10th March, 1893, with exposure of the plate during 90 minutes. It is No. 1483 in the *General Catalogue*, and is described by Sir J. Herschel as a remarkable cluster; very large; rich; pretty compressed; elongated; stars 12th to 16th mag.

Lord Rosse in his *Observations of Nebulæ and Clusters of Stars*, p. 55, 1852 to 1876, describes it as a coarse cluster; very large; straggling; irregularly round; spiral arrangement; extending about 15′ n. s. and 10′ p. f.; stars 12th to 15th mag.

The photograph shows the stars to be generally brighter and less numerous than those in the clusters M. 35 *Geminorum* and M. 36 and 37 *Aurigæ*, but it presents the same characteristics of apparent *comites* and double stars as those clusters. The photograph does not suggest the spiral arrangement referred to by Lord Rosse, and the stars are shown to about 16th mag.

Negatives of Jupiter, made with the Great Telescope of the Lick Observatory during the Opposition of 1892–3. By Edward S. Holden, W. W. Campbell, and A. L. Colton.

We have the honour to present to the Royal Astronomical Society, in the name of the Lick Observatory, a series of negatives of *Jupiter*, made with the great telescope during the opposition of 1892–3, in continuation of similar work. The following memoranda should accompany them:—

The negatives were all made on specially fast plates, prepared for us by the Cramer Company, 8 × 10 inches in size. There are usually nine images of the planet on each plate. The enlargements were directly made in the telescope, using the full aperture of 33 inches, by means of a capital amplifying lens made for the Observatory at the cost of the Smithsonian Institution, by Mr. Brashear, from calculations by Professor

C. S. Hastings, of Yale University. This lens is used so as to give a direct enlargement of about five diameters. The images under good circumstances are all that can be desired. It must be remembered, however, that the negatives are affected by the wind blowing on the telescope (and by other accidental disturbances), as if they were taken in the principal focus of a telescope 237 feet long.

Most of the exposures have been made by the three observers working together. All the plates have been developed by Mr. Colton. At first hydroquinone was used as a developer, but a pyro-developer was found to produce sharper contrasts. An exposure of two seconds is ample for the general features of the planet. Six seconds gives the satellites so that they are measurable. Each plate is marked (in Indian ink, which is presumed to be permanent) with sufficient data. The amplifying lens is set at 2·87 of its scale; the negative plate at 1·5 of the focusing scale. The times are Pacific standard times=G.M.T.−8 hours. Several negatives were made on each night, and the best have been selected for preservation at the Lick Observatory. All the others were called "duplicates," and as full a set of these as possible has been made up for presentation to the Royal Astronomical Society, irrespective of the excellence of the individual pictures, for reasons which are given in the *Monthly Notices*, vol. lii. p. 500. These negatives have been submitted to Mr. A. Stanley Williams, F.R.A.S., for examination and copying; and we take this opportunity of acknowledging his most welcome aid in the matter of the investigation and discussion of the plates.

List of Negatives of Jupiter presented to the Royal Astronomical Society.

Date.	Number of Images on the Plate.	Approximate P.S.T.	Remarks.
1892.		h m	
Oct. 20	9	8 16	No wind, but stars unsteady.
20	9	11 41	„ „
20	9	13 24	„ „
24	9	7 27	Shadow of I. on disc.
24	9	8 54	Shadows of I. and II. on disc.
24	9	10 15	
24	9	11 34	Through thick haze.
24	9	12 41	„ „
24	9	14 13	
Nov. 10	9	7 17	
10	9	9 3	
10	9	10 26	
10	9	11 42	
10	9	13 5	

Date. 1893.	Number of Images on the Plate.	Approximate P.S.T. h m	Remarks.
Jan. 17	9	7 53	Stars unsteady. Shadow of I. on disc.
18	9	6 2	
18	9	7 58	Circumstances rather poor.
18	5	8 57	Planet low.

Mount Hamilton:
1893 *January* 19.

Note on the Lick Photographs of Jupiter, 1892–3.

By A. Stanley Williams.

The series of original negatives of *Jupiter* which has just been presented to the Society by the Lick Observatory is a remarkably fine one, and should form a valuable addition to the Society's collection of photographs. The following notes may be of interest as supplementing to some extent the paper by Messrs. Holden, Campbell, and Colton, read at the May meeting of the Society.

The method employed in taking these negatives has been considerably improved upon. There are now nine separate images of the planet upon each plate, and the times of the beginnings and endings of all the exposures are exactly recorded. It will, therefore, be possible to measure the positions of markings with great accuracy and satisfaction. From some experiments that I have been making in this direction, I think that measures made upon eight or nine images will be found to give the positions of spots with greater exactness than direct micrometer measures at the telescope.

The photographs themselves are, upon the whole, a great improvement upon those of previous years. The amount of small detail shown in some of them is simply immense, and the sharpness of the images really marvellous. The magnificent enlargement of 1892 Nov. 10, which accompanies the negatives, shows well some of the qualities and capabilities of the photographs. Here we have the equatorial diameter of *Jupiter*, measuring *nearly four inches*, and yet the chief belts and markings are distinct and fairly sharp in outline. Their positions could be measured pretty exactly with a measuring instrument of no greater degree of refinement than a foot rule.

This enlargement is an interesting one in several respects. Amongst other things it shows the two oldest, or longest-known features of the planet, the chief belts of course excepted. The first of these is the great red spot and the neighbouring region. The red spot, as usual, is plainer in the photograph than it was visually in the telescope. The other marking is of a different nature altogether. On the north side of the north

equatorial belt opposite the red spot, but a little to the left of its centre, is a brighter spot, which makes a considerable indentation in the dark north equatorial belt. This spot was first recorded, by Mr. Denning, as long ago as 1885 Jan. 27. In the photograph it is plain enough even when viewed at the normal distance of vision, and it becomes quite glaringly conspicuous if the photograph be held at a distance of about four feet. Now this plainness is a curious thing, for I observed this spot frequently last year, and in the telescope it was *rather a faint spot*, so that relatively to other markings this bright spot was plainer photographically than visually last year; in this respect, therefore, it resembled the red spot, but probably from a different reason. The red spot comes out more distinctly because, on account of its reddish tint, it fails to affect the photographic plate. The bright spot, however, must, I think, have had a greenish or bluish tint, and its light has consequently caused a greater amount of photographic action than would otherwise have been the case. It may be mentioned that some of the other photographs show details in connection with this bright spot, which quite escaped my notice when observing the planet directly, although I paid a good deal of attention to the object last year. The same remark applies likewise to the red spot, and since the latter was so faint in the telescope last year, the fact that it is relatively plainer in the photographs is of great importance.

Many of the negatives in the present collection are good enough to stand enlarging considerably, though not, perhaps, to the extent of the magnificent specimen referred to above. I have been making some experiments in this direction lately, and present to the Society a positive enlarged about two diameters from the negative taken on 1892 October 24, at $12^h\ 42^m\ 28^s$–32^s P.S.T. This enlargement shows much delicate detail in the form of spots, shadings, and other markings, and hence gives some idea of the beauty and capabilities of the original negative. On a mere casual glance I counted as many as thirty-seven or thirty-eight distinct spots, including under this name little projections on the edges of the belts. Most of these spots are plain and definite enough for their positions to be readily measured. An exhaustive examination would, of course, bring out many additional details.

Immersions and Emersions of Jupiter's IV. Satellite. By Rev. S. J. Johnson, M.A.

At the Society's meeting, 1871 May 12, exactly twenty-two years ago, it was stated by Mr. Lassell that the calculations of the phenomena of *Jupiter's* satellites were "made to be used with a telescope of 46 inches focal length, but with the larger telescopes now in use the phenomena are seen at different times." The 46-inch telescope at the period referred to bore an aperture of $2\frac{3}{4}$ inches as a rule. As to the immersions and emersions of the IV. Sat. only, which are the least accurately known beforehand, the following are the differences from *Nautical Almanac* times which I have found with a telescope of this sort, viz., $3\frac{1}{4}$ inches, power employed 180.

It may readily be assumed that first or last visibility as seen with an instrument of this size would be pretty nearly equivalent to the intermediate time between first sight and full brightness in a large telescope, the mode usually adopted for observing these phenomena.

				h m s		By Naut. Alm. h m s
1877	Oct. 18	Em.		6 37 30	Haze	6 41 36
1879	Nov. 11	Em.		7 41 18		7 38 50
1884	Mar. 4	Im.		9 49 48		9 48 41
	Mar. 21	Em.		8 20 22		8 22 19
	May 10	Im.		10 2 51		10 2 25
1885	Apr. 27	Em.		8 39 45		8 35 43
1886	Mar. 11	Im.		10 34 57		10 45 2
		Em.		12 39 27		12 28 45
1890	Oct. 11	Im.		9 39 51		9 47 49
1891	Sept. 28	Em.		11 42 53	Haze	11 48 19
	Oct. 15	Em.		6 0 44		5 58 52
	Dec. 21	Em.		6 45 5		6 41 48

Difference from prediction varies from 26^s to $10^m\ 5^s$.

Melplash Vicarage, Bridport:
May 6.

Observations of the Planets Mars and Ceres, made at the Royal Observatory, Greenwich, about the time of their recent conjunction.

(*Communicated by the Astronomer Royal.*)

The observations were made with the East, or Sheepshanks, equatoreal, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power 55.

The observations are corrected for refraction, for parallax, for the error of inclination of the wires, for the motion of the planets, and for the defective illumination of *Mars*.

The two planets and the comparison stars were observed in the same position of the instrument, and the difference in the R.A. and N.P.D. of *Mars* and *Ceres* can be directly inferred from the given measures.

Mars.

Greenwich Mean Solar Time.	Observer.	Planet − ✱R.A. (corrected).	Planet − ✱N.P.D. (corrected.)	No. of Comps.	Appt. R.A. of Planet.	Secs. of Tab. R.A.	Appt. Error of Tab. R.A.	Appt. N.P.D. of Planet.	Secs. of Tab. N.P.D.	Appt. Error of Tab. N.P.D.	Comp. Stars.
1893 d h m s		m s	′ ″		h m s	s	s	° ′ ″	″	″	
Apr. 15 8 8 38	A.C.	+ 0 4·85	− 7 41·1	5	4 40 22·93	23·16	+0·23	66 44 4·0	3·9	−0·1	*a*
15 8 10 50	B.	+ 0 5·69	− 7 42·1	5	4 40 23·77	23·42	−0·35	66 44 3·0	3·4	+0·4	*a*
15 8 12 1	A.C.	− 2 56·54	− 3 16·1	2	4 40 23·08	23·56	+0·48	66 44 2·1	3·1	+1·0	*b*
15 8 23 50	B.	− 2 54·69	− 3 17·3	2	4 40 24·93	24·94	+0·01	66 44 0·9	0·4	−0·5	*b*
18 8 56 35	A.C.	+ 1 37·87	− 9 14·4	5	4 48 52·73	53·25	+0·52	66 28 3·5	5·8	+2·3	*d*
18 9 0 15	,,	+ 2 59·75	+ 2 25·3	3	4 48 53·07	53·68	+0·61	66 28 4·1	5·0	+0·9	*c*
18 9 24 18	,,	+ 0 4·87	− 1 50·7	1	...	56·49	...	...	0·0	...	*e*
24 8 50 12	,,	+11 51·22	+ 1 53·6	3	5 5 44·52	44·96	+0·44	66 1 40·5	38·9	−1·6	*f*
24 8 50 12	,,	+ 9 59·53	− 5 54·5	3	5 5 44·64	44·96	+0·32	66 1 37·0	38·9	+1·9	*g*
24 9 4 12	,,	+ 4 11·63	+ 9 8·0	1	5 5 46·31	46·60	+0·29	66 1 36·8	36·7	−0·1	*h*
25 9 17 53	B.	+12 26·99	− 4 1·8	4	5 8 37·11	37·27	+0·16	65 57 50·9	50·0	−0·9	*i*
25 9 17 53	,,	+12 23·51	+ 7 44·0	4	5 8 36·91	37·27	+0·36	65 57 56·7	50·0	−6·7	*j*
25 9 17 53	,,	+ 7 2·48	+ 5 25·1	4	5 8 37·16	37·27	+0·11	65 57 53·9	50·0	−3·9	*h*
25 9 26 3	,,	+ 2 58·68	+ 6 52·0	3	5 8 38·14	38·23	+0·09	65 57 51·2	48·7	−2·5	*k*
25 9 26 3	,,	+ 2 7·25	+14 3·3	3	5 8 38·16	38·23	+0·07	65 57 50·5	48·7	−1·8	*l*
27 9 32 18	H.	+12 42·83	− 1 35·9	3	5 14 17·49	17·35	−0·14	65 50 52·9	53·7	+0·8	*h*

Ceres.

Greenwich Mean Solar Time.	Observer.	Planet − ✱ R.A. (corrected.)	Planet − ✱ N.P.D. (corrected.)	No. of Comps.	Appt. R.A. of Planet.	Secs. of Tab. R.A.	Appt. Error of Tab. R.A.	Appt. N.P.D. of Planet.	Secs. of Tab. N.P.D.	Appt. Error of Tab. N.P.D.	Comp. Stars.
1893 d h m s		m s	′ ″		h m s	s	s	° ′ ″	″	″	
Apr. 15 8 8 4	A.C.	− 0 29·37	− 3 49·0	5	4 39 48·71	48·31	−0·40	66 47 56·1	59·1	+3·0	*a*
15 8 10 15	B.	− 0 29·22	− 3 51·9	5	4 39 48·86	48·46	−0·40	66 47 53·2	58·7	+5·5	*a*
15 8 11 27	A.C.	− 3 30·93	+ 0 34·8	2	4 39 48·69	48·54	−0·15	66 47 53·0	58·4	+5·4	*b*
15 8 23 14	B.	− 3 30·41	+ 0 33·1	2	4 39 49·21	49·34	+0·13	66 47 51·3	56·9	+5·6	*b*
18 8 52 30	A.C.	− 2 28·06	− 4 16·9	5	4 44 46·80	46·52	−0·28	66 33 1·0	7·2	+6·2	*d*
18 8 56 9	„	− 1 6·35	+ 7 23·2	3	4 44 46·97	46·77	−0·20	66 33 2·0	6·5	+4·5	*c*
18 9 20 11	„	− 4 2·69	+ 3 2·3	1	...	48·43	...	...	1·7	...	*e*
24 8 39 18	„	+ 0 55·46	+ 5 38·0	3	4 54 48·76	48·40	−0·36	66 5 24·9	23·4	−1·5	*f*
24 8 39 18	„	− 0 56·22	− 2 10·1	3	4 54 48·89	48·40	−0·49	66 5 21·4	23·4	+2·0	*g*
24 8 53 18	„	− 6 44·88	+12 54·0	1	4 54 49·80	49·38	−0·42	66 5 22·8	20·9	−1·9	*h*
25 9 5 50	B.	+ 0 22·54	− 1 2·7	4	4 56 32·66	32·27	−0·39	66 0 50·0	54·4	+4·4	*i*
25 9 5 50	„	+ 0 19·06	+10 43·2	4	4 56 32·46	32·27	−0·19	66 0 55·9	54·4	−1·5	*j*
25 9 5 50	„	− 5 1·97	+ 8 24·2	4	4 56 32·71	32·27	−0·44	66 0 53·0	54·4	+1·4	*h*
25 9 14 0	„	− 9 6·18	+ 9 52·3	3	4 56 33·28	32·85	−0·43	66 0 51·5	53·0	+1·5	*k*
25 9 14 0	„	− 9 57·61	+17 3·5	3	4 56 33·30	32·85	−0·45	66 0 50·7	53·0	+2·3	*l*
27 9 15 33	H.	− 1 36·09	− 0 15·3	7	4 59 58·57	58·18	−0·39	65 52 13·5	16·4	+2·9	*h*

The means of the apparent errors of tabular places, weighted proportionally to the number of comparisons with each star, give results as follows :—

	Day and hour d h	Error of Tab. R.A.	Error of Tab. N.P.D.	Error of Tab. Longitude.	Error of Tab. N.P.D.
Mars	Ap. 21 10	+0·20	−0·8	+2·8	−0·5
Ceres	Ap. 21 20	−0·34	+2·9	−4·9	+2·4

Comparison Stars.

Star's Name.	R.A. 1893·0. h m s	N.P.D. 1893·0. ° ′ ″	Authority.
a. W.B. (2) IV., 843	4 40 18·80	66 51 52·0	Berlin Zones, 17, 38, 41.
b. W.B. (2) IV., 918	4 43 20·32	66 47 25·2	,, ,, 11, 17, 38, 41.
c. W.B. (2) IV., 975	4 45 54·04	66 25 45·9	,, ,, 11, 17, 206, 212.
d. Lalande, 9145, –6, –7	4 47 15·57	66 37 25·0	,, ,, 11, 17, 38, 41, and 2 Paris Observations.
e. B.D. + 23°, 766	4 48 50	66 30	Bonn Observations, vol. iv.
f. W.B. (2) IV., 1168	4 53 54·02	65 59 54·1	Berlin Zones, 38.
g. W.B. (2) IV., 1213	4 55 45·82	66 7 38·7	,, ,, 215.
h. 103 Tauri	5 1 35·37	65 52 36·2	Greenwich 1880 Catalogue, and Greenwich Observations, 1891–92.
i. W.B. (2) IV., 1226	4 56 10·84	66 1 59·9	Berlin Zones, 215.
j. W.B. (2) IV., 1227	4 56 14·12	65 50 20·0	Weisse's Bessel.
k. W.B. (2) V., 53	5 5 40·13	65 51 6·7	Berlin Zones, 190, 208.
l. W.B. (2) V. 93, 94	5 6 31·58	65 43 54·8	,, ,, 190, 208.

Notes.

The tabular places of *Mars* have been interpolated from the *Nautical Almanac*; those of *Ceres* have been supplied by the Superintendent of the *Nautical Almanac*.

The initials H., A.C., B., are those of Mr. Hollis, Mr. Crommelin, and Mr. Bryant respectively.

Royal Observatory, Greenwich:
1893 *May* 9.

Ephemeris for Physical Observations

Greenwich Noon.	P	L − O.	Diff.	B	A − L.	Apparent Diameter. Equat.	Phase.	Polar.
1893.	°	°		°	°	″	″	″
June 25	344·313	275·823	406	+3·031	− 7·993	34·30	0·17	32·10
27	344·455	276·229	401	·036	8·217	34·42	·18	32·22
29	344·597	276·630	395	·041	8·436	34·55	·19	32·34
July 1	344·738	277·025	390	·047	8·650	34·69	·20	32·46
3	344·878	277·415	384	·052	8·859	34·83	·21	32·59
5	345·017	277·799	379	+3·057	− 9·062	34·97	0·22	32·73
7	345·154	278·178	373	·062	9·259	35·12	·23	32·87
9	345·289	278·551	366	·068	9·451	35·27	·24	33·01
11	345·423	278·917	360	·073	9·636	35·43	·25	33·16
13	345·556	279·277	353	·078	9·815	35·59	·26	33·31
15	345·687	279·630	346	+3·083	− 9·987	35·76	0·27	33·46
17	345·816	279·976	340	·088	10·152	35·93	·28	33·62
19	345·942	280·316	332	·093	10·310	36·10	·29	33·79
21	346·067	280·648	324	·098	10·461	36·28	·30	33·96
23	346·189	280·972	316	·103	10·604	36·47	·31	34·13
25	346·308	281·288	309	+3·108	−10·740	36·66	0·32	34·31
27	346·426	281·597	300	·113	10·868	36·85	·33	34·49
29	346·541	282·897	292	·118	10·987	37·05	·34	34·67
31	346·653	282·189	284	·122	11·098	37·25	·35	34·86
Aug. 2	346·762	282·473	275	·127	11·201	37·46	·36	35·05
4	346·868	282·748	265	+3·132	−11·295	37·67	0·36	35·25
6	346·971	283·013	256	·137	11·380	37·88	·37	35·45
8	347 070	283·269	246	·142	11·455	38·10	·38	35·66
10	347·166	283·515	237	·146	11·521	38·32	·39	35·87
12	347·259	283·752	227	·151	11·577	38·55	·39	36·08
14	347·348	283·979	216	+3·155	−11·623	38·78	0·40	36·30
16	347·433	284·195	205	·160	11 658	39·02	·40	36·52
18	347·514	284·400	195	·165	11·683	39·26	·41	36·74
20	347·591	284·595	184	·169	11·697	39·50	·41	36·97
22	347 664	284·779	172	·174	11·700	39·74	·41	37·20
24	347·732	284·951	161	+3·179	−11·692	39·99	0·41	37·43
26	347·796	285 112	150	·183	11·673	40·24	·42	37·66
28	347·856	285·262	137	·188	11·642	40·50	·42	37·90

of Jupiter, 1893-94. By A. Marth.

Greenwich Noon.	Longitude of ♃'s Central Meridian. ($877^{\circ}\cdot90$) I.	($870^{\circ}\cdot27$). II.	Corr. for Phase.	Light-time.	A − O.	B
1893.	°	°	°	m	°	°
Jun. 25	104·39	286·05	+0·28	47·210	267·8338	+3·0665
27	59·89	226·28	·29	47·038	268·0152	68
29	15·40	166·53	·31	46·861	268·1965	71
July 1	330·92	106·79	·33	46·679	268·3778	74
3	286·44	47·05	·34	46·493	268·5591	77
5	241·97	347·32	+0·36	46·302	268·7403	+3·0679
7	197·51	287·60	·37	46·107	268·9215	81
9	153·06	227·89	·39	45·907	269·1027	83
11	108·62	168·18	·40	45·703	269·2839	85
13	64·19	108·49	·42	45·495	269·4650	86
15	19·76	48·80	+0·43	45·283	269·6461	+3·0686
17	335·35	349·13	·45	45·068	269·8272	86
19	290·94	289·46	·46	44·849	270·0082	86
21	246·55	229·80	·48	44·626	270·1892	86
23	202·16	170·16	·49	44·400	270·3702	85
25	157·78	110·52	+0·50	44·171	270·5512	+3·0685
27	113·42	50·89	·51	43·939	270·7321	84
29	69·06	351·27	·52	43·705	270·9130	82
31	24·71	291·66	·53	43·468	271·0939	80
Aug. 2	340·37	232·06	·54	43·228	271·2747	78
4	296·05	172·47	+0·55	42·986	271·4555	+3·0675
6	251·73	112·90	·56	42·742	271·6363	72
8	207·42	53·33	·57	42·497	271·8170	69
10	163·13	353·77	·58	42·249	271·9977	66
12	118·84	294·22	·58	42·000	272·1784	62
14	74·57	234·69	+0·59	41·750	272·3591	+3·0658
16	30·31	175·17	·59	41·498	272·5397	54
18	346 05	115·65	·59	41·246	272·7203	49
20	301·81	56·15	·59	40·994	272·9009	44
22	257·58	356·66	·59	40·741	273 0814	39
24	213·36	297·18	+0·59	40·488	273·2619	+3·0634
26	169·16	237·71	·59	40·236	273·4424	28
28	124·96	178·25	·59	39·983	273·6228	22

Greenwich Noon.	P	L−O.	Diff.	B	A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1893	°	°		°	°	″	″	″
Aug. 30	347·911	285·399	126	·192	11·599	40·75	·42	38·14
Sept. 1	347·961	285·525	114	·196	11·544	41·01	·41	38·38
3	348·006	285·639	101	+3·201	−11·477	41·27	0·41	38·63
5	·047	285·740	88	·205	11·398	41·54	·41	38·87
7	·083	285·828	75	·210	11·306	41·80	·41	39·12
9	·113	285·903	62	·214	11·201	42·07	·40	39·37
11	·138	285·965	49	·218	11·083	42·33	·39	39·62
13	348·158	286·014	36	+3·222	−10·952	42·60	0·39	39·87
15	·173	286·050	23	·226	10·808	42·87	·38	40·12
17	·183	286·073	9	·230	10·650	43·13	·37	40·37
19	·187	286·082	4	·234	10·479	43·40	·36	40·62
21	·185	286·078	18	·238	10·295	43 66	·35	40·86
23	348·178	286 060	31	+3·241	−10·097	43·93	0·34	41·11
25	·166	286·029	44	·245	9·886	44·19	·33	41·35
27	·149	285·985	58	·248	9·662	44·45	·32	41·60
29	·126	285·927	71	·251	9·424	44·70	·30	41·84
Oct. 1	·098	285·856	84	·254	9·173	44·95	·29	42·07
3	348·064	285·772	97	+3·256	− 8·909	45·20	0·27	42·30
5	348·026	285·675	111	·259	8·632	45·44	·26	42·53
7	347·982	285·564	123	·261	8·341	45·68	·24	42·75
9	347·933	285·441	136	·263	8·038	45·91	·23	42·97
11	347·879	285·305	148	·265	7·723	46·14	·21	43·18
13	347·820	285·157	160	+3·267	− 7·395	46·35	0·19	43·38
15	347·757	284 997	171	·268	7·056	46·56	·18	43·58
17	347·690	284·826	182	·268	6·705	46·76	·16	43·76
19	347·618	284·644	193	·269	6·343	46·95	·14	43·94
21	347·542	284·451	203	·269	5·971	47·14	·13	44·11
23	347·463	284·248	212	+3·269	− 5·589	47·31	0·11	44·27
25	347·380	284·036	221	·268	5·197	47·47	·10	44·42
27	347·293	283·815	230	·268	4·797	47 62	·08	44·56
29	347·203	283·585	237	·267	4·388	47·75	·07	44·69
31	347·111	283·348	244	·265	3·971	47·88	·06	44·81
Nov. 2	347·016	283·104	251	+3·263	− 3·547	47 99	0·05	44·91
4	346·919	282·853	257	·260	3·117	48·09	·04	45·00
6	346·820	282·596	261	·257	2·681	48·17	·03	45·08
8	346·720	282·335	266	·254	2·241	48·24	·02	45·15
10	346·618	282·069	269	·250	1·796	48·30	·01	45·20

Greenwich Noon.	Longitude of ♃'s Central Meridian. (877°·90) L	(870°·27). II.	Corr. for Phase.	Light-time.	A−O.	B
1893.	°	°	°	m	°	°
Aug. 30	80·78	118·81	·58	39·732	273·8032	·0616
Sept. 1	36·61	59·37	·58	39·481	273·9836	·0610
3	352·44	359·95	+0·57	39·231	274·1639	+3·0603
5	308·29	300·54	·56	38·983	274·3442	·0596
7	264·16	241·14	·56	38·736	274·5245	·0589
9	220·03	181·75	·55	38·492	274·7047	·0581
11	175·91	122·38	·53	38·250	274·8849	·0573
13	131·81	63·01	+0·52	38·010	275·0651	+3·0564
15	87·72	3·66	·51	37·773	275·2452	·0555
17	43·64	304·32	·49	37·540	275·4253	·0546
19	359·57	244·99	·48	37·310	275·6054	·0537
21	315·51	185·67	·46	37·084	275 7855	·0527
23	271·47	126·36	+0·44	36·862	275·9655	+3·0517
25	227·43	67·06	·43	36·644	276·1455	·0507
27	183·40	7·78	·41	36·431	276·3254	·0496
29	139·39	308·50	·39	36·223	276·5053	·0485
Oct. 1	95·39	249·23	·37	36·021	276·6852	·0474
3	51·39	189·98	+0·35	35·824	276·8650	+3·0463
5	7·40	130·73	·32	35·632	277·0448	·0451
7	323·43	71·49	·30	35·447	277·2246	·0439
9	279·46	12·26	·28	35·269	277·4043	·0427
11	235·50	313·04	·26	35·098	277·5840	·0414
13	191·55	253·83	+0·24	34·933	277·7637	+3·0401
15	147·60	194·63	·22	34·776	277·9433	·0388
17	103·66	135·43	·20	34·627	278·1229	·0374
19	59·73	76·24	·18	34·486	278·3025	·0360
21	15·80	17·05	·16	34·353	278·4820	·0346
23	331·88	317·87	+0·14	34·229	278·6615	+3·0332
25	287·96	258·69	·12	34·113	278·8410	·0317
27	244·05	199·51	·10	34·006	279·0204	·0302
29	200·14	140·34	·08	33·909	279·1998	·0287
31	156·23	81·17	·07	33·821	279·3791	·0272
Nov. 2	112·33	22·00	+0·06	33·742	279·5584	+3·0256
4	68·42	322·84	·04	33·673	279·7377	·0240
6	24·51	263·67	·03	33·614	279·9169	·0224
8	340·60	204·50	·02	33·565	280·0961	·0207
10	296·69	145·33	·01	33·526	280·2753	·0190

Greenwich Noon.	P	L−O.	Diff.	B	A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1893.	°	°		°	°	″	″	″
Nov. 12	346·515	281·800	271	+3·246	− 1·348	48·34	0·01	45·24
14	346·412	281·529	273	·241	0·898	48·37	·00	45·26
16	346·308	281·256	273	·236	− 0·446	48·38	·00	45·27
18	346·205	280·983	273	·231	+ 0·006	48·37	·00	45·27
20	346·102	280·710	272	·225	0·458	48·35	·00	45·25
22	346·000	280·438	270	+3·219	+ 0·909	48·32	·00	45·22
24	345·898	280·168	267	·212	1·358	48·27	·01	45·17
26	345·798	279·901	264	·205	1·804	48·21	·01	45·11
28	345·700	279·637	260	·198	2·247	48·13	·02	45·04
30	345 604	279·377	255	·190	2·686	48·04	·03	44·96
Dec. 2	345·510	279·122	248	+3·182	+ 3·119	47·93	0·04	44·86
4	345·418	278·874	242	·174	3·546	47·81	·05	44·75
6	345·328	278·632	235	·166	3·967	47·68	·06	44·62
8	345·242	278·397	227	·157	4·381	47·53	·07	44·48
10	345·159	278·170	218	·148	4·786	47·37	·08	44·33
12	345·080	277·952	208	+3·138	+ 5·182	47·20	0·10	44·17
14	345·004	277·744	198	·129	5·569	47·02	·11	44·00
16	344·932	277·546	188	·120	5·946	46·83	·13	43·82
18	·864	277·358	177	·110	6·313	46·62	·14	43·63
20	·800	277·181	166	·100	6·668	46·41	·16	43·43
22	344·740	277·015	154	+3·090	+ 7·012	46·19	0·17	43·23
24	·685	276·861	141	·080	7·344	45·96	·19	43·02
26	·634	276·720	129	·070	7·664	45·73	·20	42·80
28	·597	276·591	116	·060	7·971	45·49	·22	42·57
30	·545	276·475	103	·050	8·265	45·24	·23	42·34
1894.								
Jan. 1	344·508	276·372	90	+3·040	+ 8·547	44·98	0·25	42·10
3	·476	·282	76	3·030	8·815	44·72	·26	41·85
5	·448	·206	63	3·021	9·069	44·46	·28	41·60
7	·425	·143	49	3 011	9·310	44·19	·29	41·35
9	·407	·094	35	3·001	9·537	43·92	·30	41·10
11	344·394	276·059	21	+2 991	+ 9·750	43·64	0·32	40·85
13	·386	·038	8	2·982	9·949	43·37	·33	40·59
15	·383	·030	7	2·973	10·134	43·09	·34	40·33
17	·384	·037	21	2·964	10·305	42·81	·35	40·07
19	·391	·058	34	2·955	10·462	42·53	·35	39·81
21	344·402	276·092	47	+2·946	+10·606	42·25	0·36	39·55

Greenwich Noon.	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27). II.	Corr. for Phase.	Light-time.	A−O.	B
1893.	°	°	°	m	°	°
Nov. 12	252·78	86·16	+0·01	33·498	280·4544	+3·0172
14	208·86	26·98	·00	33·480	280·6335	·0154
16	164·94	327·80	...	33·472	280·8126	·0136
18	121·01	268·61	...	33·475	280·9916	·0118
20	77·07	209·41	...	33·488	281·1706	·0100
22	33·13	150·21	−0·00	33·511	281·3495	+3·0081
24	349·18	91·00	·01	33·545	281·5284	·0062
26	305·22	31·78	·01	33·590	281·7072	·0043
28	261·25	332·55	·02	33·644	281·8860	·0023
30	217·27	273·31	·03	33·709	282·0648	3·0003
Dec. 2	173·28	214·06	−0·04	33·784	282·2436	+2·9983
4	129·28	154·80	·05	33·869	282·4223	·9962
6	85·26	95·52	·07	33·963	282·6010	·9941
8	41·23	36·23	·08	34·068	282·7796	·9920
10	357·19	336·93	·10	34·182	282·9582	·9898
12	313·13	277·61	−0·12	34·305	283 1368	+2·9877
14	269·06	218·28	·14	34·438	283·3153	·9855
16	224·97	158·93	·15	34·579	283·4938	·9833
18	180·87	99·57	·17	34·729	283·6722	·9811
20	136·75	40·19	·19	34·888	283·8506	·9788
22	92·61	340·80	−0·21	35·054	284·0290	+2·9765
24	48·46	281·39	·24	35·228	284·2073	·9742
26	4·29	221·96	·26	35·410	284·3856	·9718
28	320·10	162·51	·28	35·599	284·5639	·9694
30	275·90	103·05	·30	35·795	284·7421	·9670
1894.						
Jan. 1	231·68	43·57	−0·32	35·998	284·9203	+2·9646
3	187·44	344·08	·34	36·207	285·0984	·9621
5	143·19	284·56	·36	36·422	285·2765	·9596
7	98·92	225·03	·38	36·643	285·4546	·9571
9	54·63	165·48	·40	36·869	285·6326	·9546
11	10·32	105·92	−0·41	37·101	285·8106	+2·9520
13	326·00	46·34	·43	37·337	285·9885	·9494
15	281·66	346·74	·45	37·577	286·1664	·9468
17	237·30	287·13	·46	37·822	286·3443	·9441
19	192·93	227·50	·48	38·070	286·5221	·9414
21	148·54	167·85	−0·49	38·321	286·6999	+2·9387

Greenwich Noon.		P	L−O.	Diff.	B	A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1894.		°	°		°	°	″	″	″
Jan.	23	344·418	·139	61	2·937	10·736	41·98	·37	39·28
	25	·438	·200	75	2·929	10·852	41·70	·37	39·02
	27	·464	·275	88	2·920	10·955	41·42	·38	38·76
	29	·494	·363	101	2·912	11·045	41·14	·38	38·50
	31	344·529	276·464	113	+2·904	+11·122	40 87	0·38	38·25
Feb.	2	·569	·577	127	2·897	11·186	40·60	·39	37·99
	4	·613	·704	139	2·889	11·237	40·33	·39	37·74
	6	·662	·843	151	2·882	11·276	40·06	·39	37·49
	8	·715	276·994	163	2·874	11·302	39·80	·39	37·24
	10	344·773	277·157	176	+2·867	+11·316	39·54	0·38	37·00
	12	·835	277·333	187	2·861	11·318	39·28	·38	36·76
	14	·901	277·520	198	2·854	11·308	39·02	·38	36·52
	16	344·972	277·718	209	2·848	11·287	38·77	·37	36·28
	18	345·047	277·927	220	2·841	11·255	38·52	·37	36·04
	20	345·126	278 147	231	+2·835	+11·212	38·28	0·37	35·83
	22	345·209	278·378	240	2·829	11·159	38·04	·36	35·60
	24	345·296	278·618	250	2·823	11·095	37·81	·35	35·38
	26	345·387	278·868	261	2·818	11·021	37·58	·35	35·17
	28	345·482	279·129	270	2·813	10·938	37·35	·34	34·96
Mar.	2	345·581	279·399	279	+2·807	+10·845	37·13	0·33	34·75
	4	345·684	279·678	288	2·802	10·743	36·91	·32	34·55
	6	345·791	279·966	297	2·797	10·632	36·70	·32	34·35
	8	345·901	280·263	306	2·792	10·512	36·49	·31	34·15
	10	346·015	280·569	314	2·787	10·383	36·29	·30	33·96
	12	346·132	280·883	322	+2·783	+10·246	36·09	0·29	33·78
	14	346·253	281·205	329	2·778	10·101	35·90	·28	33·60
	16	346·378	281·534	336	2·774	9·948	35·71	·27	33·42
	18	346·506	281·870	344	2·770	9·787	35·53	·26	33·25
	20	346·637	282·214	351	2·765	9·620	35·35	·25	33·08
	22	346·771	282·565	358	+2·761	+ 9·446	35·18	0·24	32·92
	24	346·909	282·923	364	2·756	9·265	35·01	·23	32·76
	26	347·050	283·287	370	2·752	9·078	34·84	·22	32·61
	28	347·193	283·657	376	2·748	8·884	34·68	·21	32·46
	30	347·340	284·033	382	2·744	8·684	34·53	·20	32·31
Apr.	1	347·489	284·415		+2·740	+ 8·478	34·38	0·19	32·17

Greenwich Noon.	Longitude of ♃'s Central Meridian. ($877^{\circ}\cdot90$) I.	($870^{\circ}\cdot27$). II.	Corr. for Phase.	Light-time.	A−O.	B
1894.	°	°	°	m	°	°
Jan. 23	104·14	108·19	·50	38·576	286·8776	·9359
25	59·72	48·51	·51	38·833	287·0553	·9331
27	15·29	348·82	·52	39·093	287·2330	·9303
29	330·84	289·11	·53	39·356	287·4106	·9275
31	286·38	229·39	−0·54	39·620	287·5882	+2·9246
Feb. 2	241·91	169·66	·54	39·885	287·7657	·9217
4	197·42	109·91	·55	40·152	287·9432	·9188
6	152·92	50·15	·55	40·420	288·1207	·9159
8	108·40	350·38	·55	40·689	288·2981	·9129
10	63·87	290·59	−0·56	40·958	288·4755	+2·9099
12	19·33	230·79	·56	41·227	288·6528	·9069
14	334·78	170·98	·56	41·496	288·8301	·9038
16	290·22	111·16	·55	41·764	289·0073	·9007
18	245·65	51·33	·55	42·032	289·1845	·8976
20	201·07	351·49	−0·55	42·298	289·3617	+2·8945
22	156·47	291·64	·54	42·564	289·5388	·8913
24	111·87	231·78	·54	42·828	289·7159	·8881
26	67·26	171·91	·53	43·090	289·8929	·8849
28	22·64	112·03	·52	43·350	290·0699	·8816
Mar. 2	338·01	52·14	−0·51	43·609	290·2468	+2·8783
4	293·38	352·25	·50	43·866	290·4237	·8750
6	248·74	292·35	·49	44·120	290·6006	·8717
8	204·09	232·44	·48	44·371	290·7774	·8683
10	159·43	172·52	·47	44·619	290·9542	·8649
12	114·77	112·60	−0·46	44·863	291·1309	+2·8615
14	70·10	52·67	·44	45·105	291·3076	·8581
16	25·42	352·74	·43	45·343	291·4842	·8546
18	340·74	292·80	·42	45·577	291·6608	·8511
20	296·06	232·86	·40	45·808	291·8374	·8476
22	251·37	172·91	−0·39	46·034	292·0139	+2·8441
24	206·68	112·96	·37	46·256	292·1904	·8405
26	161·98	53·01	·36	46·474	292·3668	·8369
28	117·28	353·05	·34	46·688	292·5432	·8333
30	72·58	293·09	·33	46·897	292·7195	·8297
Apr. 1	27·87	233·12	−0·31	47·102	292·8958	+2·8261

P is the position-angle of the polar axis of *Jupiter*; L − O + 180° the jovicentric longitude of the Earth, reckoned in the assumed plane of the planet's equator from O, the point of the vernal equinox of *Jupiter's* northern hemisphere, or the point of the descending node of the planet's equator on its orbit. B denotes the jovicentric latitude of the Earth above *Jupiter's* equator; A − L the annual parallax or the difference between the jovicentric longitudes of the Sun and the Earth. For the computation of the apparent diameters of the disc, the values deduced by Schur (*Astron. Naehr.*, vol. 129, p. 14), which were adopted in the ephemeris for the preceding apparition, have been retained.

The two values of the "Longitude of ♃'s Central Meridian" have been computed with the same rates of rotation as in the ephemerides for some preceding years, and without any shifting of the zero-meridians from the positions adopted in the last ephemeris. The differences of successive values of the longitudes for the intervals of two days vary for System I. between 1755°·29 and 1756°·10; and for System II. between 1740°·03 and 1740°·84. The addition of the "correction for phase" to the longitude of the central meridian gives the longitude of the meridian which bisects the illuminated disc. The following is a list of Greenwich mean times, when the zero-meridian in the assumed two systems of longitudes will pass the middle of the illuminated disc:—

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
1893	h m	h m	1893	h m	h m
June 25	16 49·5	21 53·5	July 7	24 7·1	21 50·7
26	22 21·3	17 45·0	8	9 57·7	7 46·5
27	8 11·9	13 36·6		19 48·3	17 42·2
	18 2·4	23 32·3	9	15 29·4	13 33·7
28	13 43·6	9 28·1		25 20·0	23 29·5
	23 34·2	19 23·9	10	11 10·6	9 25·3
29	19 15·4	15 15·4		21 1·2	19 21·0
30	14 56·6	11 7·0	11	16 42·3	15 12·5
	24 47·2	21 2·7	12	12 23·4	11 4·0
July 1	20 28·3	16 54·3		22 14·0	20 59·8
2	16 9·5	22 41·6	13	17 55·2	16 51·3
3	11 50·7	8 37·3	14	13 36·3	12 42·8
	21 41·3	18 33·1		23 26·9	22 38·5
4	17 22·4	14 24·6	15	9 17·4	8 34·3
5	22 54·2	20 11·9		19 8·0	18 30·0
6	18 35·4	16 3·4	16	14 49·1	14 21·5
7	14 16·5	11 54·9	17	0 39·7	0 17·3

1893	I. (877°·90) h m	II. (870°·27) h m	1893	I. (877°·90) h m	II. (870°·27) h m
July 17	10 30·3	10 13·0	Aug. 7	8 28·3	12 35·1
	20 20·8	20 8·7		18 18·8	22 30·8
18	16 2·0	16 0·2	8	13 59·9	8 26·5
19	11 43·1	11 51·7		23 50·4	18 22·2
	21 33·6	21 47·5	9	9 40·9	14 13·6
20	17 14·8	17 38·9		19 31·5	24 9·3
21	12 55·9	13 30·4	10	15 12·5	10 5·1
	22 46·4	23 26·1		25 3·0	20 0·8
22	8 36·0	9 21·9	11	10 53·6	15 52·2
	18 27·6	19 17·6		20 44·1	25 47·9
23	14 8·7	15 9·1	12	6 34·6	11 43·6
	23 59·2	25 4·8		16 25·1	21 39·3
24	9 49·8	11 0·5	13	12 6·2	7 35·0
	19 40·3	20 56·3		21 56·7	17 30·7
25	15 21·4	16 47·7	14	7 47·2	13 22·1
26	11 2·6	12 39·2		17 37·7	23 17·8
	20 53·1	22 34·9	15	13 18·8	9 13·5
27	16 34·2	18 26·4		23 9·3	19 9·2
28	12 15·3	14 17·9	16	8 59·8	15 0·6
	22 5·9	24 13·6		18 50·3	24 56·3
29	7 56·4	10 9·3	17	14 31·4	10 51·9
	17 47·0	20 5·0		24 21·9	20 47·6
30	13 28·0	6 0·8	18	10 12·4	6 43·3
	23 18·6	15 56·5		20 2·9	16 39·0
31	9 9·1	11 47·9	19	5 53·4	12 30·4
	18 59·7	21 43·6		15 44·0	22 26·1
Aug. 1	14 40·8	7 39·4	20	11 25·0	8 21·8
	24 31·3	17 35·1		21 15·5	18 17·5
2	10 21·8	13 26·5	21	7 6·0	24 8·9
	20 12·4	23 22·2		16 56·5	14 4·5
3	6 2·9	9 18·0	22	12 37·5	10 0·2
	15 53·5	19 13·7		22 28·0	19 55·9
4	11 34·5	15 5·1	23	8 18·6	5 51·6
	21 25·1	25 0·8		18 9·1	15 47·3
5	7 15·6	10 56·5	24	13 50·1	11 38·6
	17 6·1	20 52·3		23 40·6	21 34·3
6	12 47·2	6 48·0	25	9 31·1	7 30·0
	22 37·8	16 43·7		19 21·6	17 25·7

1893	I. (877°·90) h m	II. (870°·27) h m	1893	I. (877°·90) h m	II. (870°·27) h m
Aug. 26	15 2·6	13 17·0	Sept. 14	11 44·8	13 57·5
	24 53·1	23 12·7		21 35·3	23 53·1
27	10 43·6	9 8·4	15	7 25·7	9 48·7
	20 34·1	19 4·1		17 16·2	19 44·4
28	6 24·6	14 55·4	16	12 57·1	5 40·0
	16 15·1	24 51·1		22 47·6	15 35·7
29	11 56·1	10 46·8	17	8 38·1	11 26·9
	21 46·5	20 42·4		18 28·5	21 22·6
30	7 37·0	6 38·1	18	14 9·5	7 18·2
	17 27·5	16 33·8		23 59·9	17 13·9
31	13 8·5	12 25·1	19	9 50·4	13 5·1
	22 59·0	22 20·8		19 40·8	23 0·8
Sept. 1	8 49·5	8 16·5	20	5 31·3	8 56·4
	18 40·0	18 12·1		15 21·8	18 52·0
2	14 21·0	14 3·5	21	11 2·7	14 43·3
	24 11·5	23 59·1		20 53·1	24 38·9
3	10 2·0	9 54·8	22	6 43·6	10 34·6
	19 52·4	19 50·5		16 34·0	20 30·2
4	5 42·9	5 46·1	23	12 14·9	6 25·8
	15 33·4	15 41·8		22 5·4	16 21·4
5	11 14·4	11 33·1	24	7 55·8	12 12·7
	21 4·9	21 28·7		17 46·3	22 8·3
6	6 55·3	7 24·3	25	13 27·2	8 4·0
	16 45·8	17 20·0		23 17·6	17 59·6
7	12 26·8	13 11·4	26	9 8·1	13 50·8
	22 17·3	23 7·1		18 58·5	23 46·5
8	8 7·7	9 2·7	27	14 39·4	9 42·1
	17 58·2	18 58·4		24 29·9	19 37·7
9	13 39·2	14 49·7	28	10 20·3	5 33·3
	23 29·6	24 45·3		20 10·7	15 28·9
10	9 20·1	10 41·0	29	6 1·2	11 20·2
	19 10·6	20 36·6		15 51·6	21 15·8
11	14 51·5	6 32·3	30	11 32·5	7 11·4
	24 42·0	16 27·9		21 22·9	17 7·0
12	10 32·5	12 19·2	Oct. 1	7 13·4	12 58·3
	20 22·9	22 14·9		17 3·8	22 53·9
13	6 13·4	8 10·5	2	12 44·7	8 49·5
	16 3·9	18 6·2		22 35·1	18 45·1

1893	I. (877°·90) h m	II. (870°·27) h m	1893	I. (877°·90) h m	II. (870°·27) h m
Oct. 3	8 25·6	14 36·3	Oct. 22	5 5·1	5 18·3
	18 16·0	24 32·0		14 55·5	15 13·9
4	13 56·9	10 27·6	23	10 36·3	11 5·1
	23 47·3	20 23·2		20 26·7	21 0·6
5	9 37·8	6 18·8	24	6 17·1	6 56·2
	19 28·2	16 14·4		16 7·5	16 51·8
6	5 18·6	12 5·6	25	11 48·4	12 43·0
	15 9·0	22 1·2		21 38·8	22 38·6
7	10 49·9	7 56·8	26	7 29·2	8 34·2
	20 40·3	17 52·4		17 19·6	18 29·8
8	6 30·8	13 43·6	27	13 0·4	4 25·3
	16 21·2	23 39·2		22 50·8	14 20·9
9	12 2·1	9 34·8	28	8 41·2	10 12·0
	21 52·5	19 30·5		18 31·6	20 7·7
10	7 42·9	5 26·1	29	4 22·0	6 3·3
	17 33·3	15 21·7		14 12·4	15 58·9
11	13 14·2	11 12·9	30	9 53·3	11 50·0
	23 4·6	21 8·5		19 43·7	21 45·6
12	8 55·0	7 4·0	31	5 34·1	7 41·2
	18 45·5	16 59·6		15 24·5	17 36·8
13	14 26·3	12 50·8	Nov. 1	11 5·3	13 27·9
	24 16·7	22 46·4		20 55·7	23 23·5
14	10 7·1	8 42·0	2	6 46·1	9 19·1
	19 57·6	18 37·6		16 36·5	19 14·7
15	5 48·0	14 28·8	3	12 17·3	5 10·2
	15 38·4	24 24·4		22 7·7	15 5·8
16	11 19·2	10 20·0	4	7 58·1	10 57·0
	21 9·7	20 15·6		17 48·5	20 52·6
17	6 59·1	6 11·2	5	13 29·3	6 48·2
	16 50·5	16 6·8		23 19·7	16 43·7
18	12 31·3	11 58·0	6	9 10·2	12 34·9
	22 21·7	21 53·6		19 0·6	22 30·5
19	8 12·2	7 49·2	7	4 51·0	8 26·1
	18 2·6	17 44·7		14 41·4	18 21·6
20	13 43·4	13 35·9	8	10 22·2	4 17·2
	23 33·8	23 31·5		20 12·6	14 12·8
21	9 24·2	9 27·1	9	6 3·0	10 4·0
	19 14·7	19 22·7		15 53·4	19 59·5

	I. (877°·90)		II. (870°·27)			I. (877°·90)		II. (870°·27)	
1893	h	m	h	m	1893	h	m	h	m
Nov. 10	11	34·2	5	55·1	Nov. 29	8	13·3	6	32·3
	21	24·6	15	50·7		18	3·7	16	27·9
11	7	15·0	11	41·9	30	3	54·1	2	23·5
	17	5·4	21	37·5		13	44·6	12	19·1
12	2	55·8	7	33·0	Dec. 1	9	25·4	8	10·3
	12	46·2	17	28·6		19	15·9	18	5·9
13	8	27·1	3	24·2	2	5	6·3	4	1·5
	18	17·5	13	19·8		14	56·7	13	57·1
14	4	7·9	9	10·9	3	10	37·6	9	48·3
	13	58·3	19	6·5		20	28·0	19	44·0
15	9	39·1	5	2·1	4	6	18·5	5	39·6
	19	29·5	14	57·7		16	8·9	15	35·2
16	5	19·9	10	48·9	5	1	59·4	1	30·8
	15	10·3	20	44·4		11	49·8	11	26·4
17	10	51·1	6	40·0	6	7	30·7	7	17·7
	20	41·5	16	35·6		17	21·1	17	13·3
18	6	31·9	12	26·8	7	3	11·6	3	8·9
	16	22·4	22	22·4		13	2·0	13	4·6
19	2	12·8	8	18·0	8	8	42·9	8	55·8
	12	3·2	18	13·5		18	33·4	18	51·4
20	7	44·0	4	9·1	9	4	23·9	4	47·1
	17	34·4	14	4·7		14	14·3	14	42·7
21	3	24·8	9	55·9	10	9	55·2	10	34·0
	13	15·3	19	51·5		19	45·7	20	29·6
22	8	56·1	5	47·1	11	5	36·1	6	25·2
	18	46·5	15	42·7		15	26·6	16	20·9
23	4	36·9	1	38·3	12	1	17·1	2	16·5
	14	27·3	11	33·9		11	7·5	12	2·2
24	10	8·2	7	25·1	13	6	48·5	8	3·4
	19	58·6	17	20·7		16	38·9	17	59·1
25	5	49·0	3	16·3	14	2	29·4	3	54·7
	15	39·4	13	11·8		12	19·9	13	50·4
26	1	29·9	9	3·0	15	8	0·8	9	41·6
	11	20·3	18	58·6		17	51·3	19	37·3
27	7	1·1	4	54·2	16	3	41·7	5	32·9
	16	51·6	14	49·8		13	31·2	15	28 6
28	2	42·0	0	45·4	17	9	13·1	1	24·2
	12	32·4	10	41·1		19	3·6	11	19·9

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
1893	h m	h m	1894	h m	h m
Dec. 18	4 54·1	7 11·2	Jan. 3	4 43·6	0 26·9
	14 44·6	17 6·8		14 34·1	10 22·6
19	10 25·5	3 2·5	4	0 24·7	6 14·0
	20 16·0	12 58·2		10 15·2	16 9·7
20	6 6·5	8 49·5	5	5 56·2	2 5·4
	15 57 0	18 45·1		15 46·8	12 1·1
21	1 47·5	4 40·8	6	1 37·3	7 52·5
	11 37·9	14 36·5		11 27·8	17 48·3
22	7 18·9	10 27·8	7	7 8·9	3 44·0
	17 9·4	20 23·5		16 59·4	13 39·7
23*	2 59·9	6 19·1	8	2 50·0	9 31·1
	12 50·4	16 14·8		12 40·5	19 26·8
24	8 31·1	2 10·5	9	8 21·6	5 22·5
	18 21·9	12 6·1		18 12·1	15 18·3
25	4 12·4	7 57·5	10	4 2·7	1 14·0
	14 2·9	17 53·2		13 53·2	11 9·7
26	9 43·9	3 48·8	11	9 34·3	7 1·1
	19 34·4	13 44·5		19 24·8	16 56·9
27	5 24·9	9 35·9	12	5 15·4	2 52·6
	15 15·4	19 31·6		15 5·9	12 48·3
28	1 5·9	5 27·2	13	0 56·5	8 39·8
	10 56·4	15 22·9		10 47·0	18 35·5
29	6 37·4	1 18·6	14	6 28·1	4 31·2
	16 27·9	11 14·3		16 18·7	14 26·9
30	2 18·4	7 5·7	15	2 9·2	0 22·7
	12 8·9	17 1·4		11 59·8	10 18·4
31	7 50·0	2 57·0	16	7 40·9	6 9·9
	17 40·5	12 52·7		17 31·5	16 5·6
1894.			17	3 22·0	2 1·3
Jan. 1	3 31·0	8 44·1		13 12·6	11 57·1
	13 21·5	18 39·8	18	8 53·7	7 48·6
2	9 2·6	4 35·5		18 44·3	17 44·3
	18 53·1	14 31 2	19	4 34·9	3 40·1

* On Dec. 23 a Transit of *Venus* across the Sun's disc will take place for *Jupiter's* system. On page 162 of vol. xlvi. of the *Monthly Notices* a list is given of the transits which have occurred since 1830, to which may now be added

1893 Dec. 23·4 hel. long. 59°·5.

	I. (877°·90)		II. (870°·27)			I. (877°·90)		II. (870°·27)	
1894	h	m	h	m	1894	h	m	h	m
Jan. 19	14	25·4	13	35·8	Feb. 15	6	14·1	11	1·1
20	10	6·5	9	27·3	16	1	55·4	6	52·7
21	5	47·7	5	18·8	17	7	27·2	12	40·1
	15	38·3	15	14·5	18	3	8·5	8	31·8
22	1	28·8	1	10·3	19	8	40·4	4	23·4
	11	19·4	11	6·0	20	4	21·6	10	10·8
23	7	0·5	6	57·5	21	9	53·5	6	2·4
	16	51·1	16	53·3	22	5	34·8	11	49·8
24	2	41·7	2	49·0	23	1	16·1	7	41·5
	12	32·3	12	44·8	24	6	48·0	13	28·9
25	8	13·4	8	36·3	25	2	29·2	9	20·5
26	3	54·6	4	27·8	26	8	1·1	5	12·2
	13	45·2	14	23·6	27	3	42·4	1	3·8
27	9	26·3	10	15·1		13	33·1	10	59·6
28	5	7·5	6	6·6	28	9	14·3	6	51·3
	14	58·1	16	2·4	Mar. 1	4	55·6	2	42·9
29		48·7	1	58·2		14	46·3	12	38·7
	10	38·3	11	54·0	2	10	27·5	8	30·4
30	6	20·5	7	45·5	3	6	8·8	4	22·0
31	2	1·7	3	37·0	4	1	50·1	0	13·7
	17	52·2	13	32·8		11	40·8	10	9·5
Feb. 1	7	33·4	9	24·3	5	7	22·0	6	1·1
2	3	14·6	5	15·9	6	3	3·3	1	52·8
	13	5·2	15	11·7		12	54·0	11	48·6
3	8	46·4	11	3·2	7	8	35·3	7	40·3
4	4	27·6	6	54·8	8	4	16·6	3	31·9
5	0	8·8	2	46·3		14	7·2	13	27·7
	9	59·4	12	42·1	9	9	48·5	9	19·4
6	5	40·6	8	33·7	10	5	29·8	5	11·1
7	1	21·8	4	25·3		15	20·5	15	6·9
	11	12·4	14	21·1	11	11	1·8	10	58·6
8	6	53·7	10	12·6	12	6	43·1	6	50·2
9	2	34·9	6	4·2	13	2	24·4	2	41·9
10	8	6·7	11	51·6		12	15·1	12	37·7
11	3	48·0	7	43·2	14	7	56·4	8	29·4
12	9	19·8	3	34·8	15	3	37·7	4	21·1
13	5	1·0	9	22·1		13	28·3	14	16·9
14	10	32·9	5	13·7	16	9	9·6	10	8·6

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
1894	h m	h m	1894	h m	h m
March 17	4 51·0	6 0·2	March 24	4 12·2	6 49·5
18	10 22·9	11 47·7	25	9 44·2	12 37·0
19	6 4·3	7 39·4	26	5 25·5	8 28·7
20	11 36·2	13 26·9	28	6 38·8	10 7·9
21	7 17·6	9 18·6	29	2 20·1	5 59·6
22	2 58·9	5 10·3	30	7 52·1	11 47·1
23	8 30·9	10 57·8	31	3 33·4	7 38·8

The intervals between successive passages or crossings vary in System I. between $9^h\ 50^m{\cdot}40$ and $50^m{\cdot}67$ and in II. between $9^h\ 55^m{\cdot}58$ and $55^m{\cdot}85$.

Colonel Cooper's Observatory,
Markree, Collooney, Ireland.

Errata in Monthly Notices, lii., 1 (1891 *November*), *p.* 27, *Wolf's Comet* (*b* 1891).

$\mathcal{E}$ – **d* N.P.D., for + 2′ 25″·7 read + 2′ 28″·2.

$\mathcal{E}$ – **e* N.P.D., for + 13 31·0 read + 14 5·6.

$\mathcal{E}$ – **f* N.P.D., for – 1 20·5 read – 1 18·8.

Appt. N.P.D. of $\mathcal{E}$ from * *e* for 77° 11′ 44″·2 read 77° 12′ 26″·7.

Appt. N.P.D. of $\mathcal{E}$ from * *f* for 77 40 50·1 read 77 40 48·4.

In the N.P.D. of $\mathcal{E}$ deduced from * *e* the N.P.D. of the latter given in the footnote, viz., 76° 58′ 41″·5, has been adopted, as it was confirmed by subsequent observations.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIII. JUNE 9, 1893. No. 8

Captain W. DE W. ABNEY, C.B., R.E., D.C.L., F.R.S., President, in the Chair.

Hedley Robert Beasley, Milldown School, Blandford, Dorset;
Edwin Bailey Elliott, M.A., F.R.S., Waynflete Professor of Pure Mathematics, Oxford;
Arthur E. Kennelly, Edison's Laboratory, Orange, New Jersey, U.S.A.;
Benjamin Theophilus Moore, M.A., Longwood, Bexley, Kent;
Arthur A. Rambaut, D.Sc., Royal Astronomer of Ireland, Observatory, Dunsink, co. Dublin;
Frederick Lumb Wanklyn, Grand Trunk Railway Company, Montreal, Canada,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Edmond Herbert Hills, Captain R.E., 1 Devonshire Place, W. (proposed by Capt. W. de W. Abney);
Charles Herbert Edmund Rea, 223 Norwood Road, Herne Hill, S.E. (proposed by W. S. B. Woolhouse);
William Shackleton, Computer to the Solar Physics Committee, Royal College of Science, South Kensington, S.W. (proposed by J. Norman Lockyer).

Fifty-nine presents were announced as having been received since the last meeting, including, amongst others,

A. A. Michelson, On the application of interference methods to spectroscopic measurement, presented by the author; Rev. S. Kinns, Graven in the Rock, presented by the author; Photographs of the Lick Observatory, presented by the Observatory.

Preliminary Report of the Joint Solar Eclipse Committee of the Royal Society, the Royal Astronomical Society, and the Solar Physics Committee on the Observations of the Solar Eclipse of 1893 *April* 16. By A. A. Common, LL.D., F.R.S., Secretary to the Joint Solar Eclipse Committee.

Abstract.

The Joint Committee have requested me to make the following brief report on the observations of the eclipse. This will be followed shortly by a more complete report.

The Joint Committee was formed early in 1892; a grant of money was obtained from the Government Grant Fund of the Royal Society, and preparations were at once begun. After due consideration it was decided to send out two observing expeditions, one to Fundium, on the Salum River, in Senegambia, and one to Pará-Curu, in the Province of Ceará, in the northern part of Brazil. With the exception of the work undertaken by Professor Thorpe, the whole of the observations were photographic. Three classes of work were undertaken at each station.

1st. Photographs of the Corona, in continuation of a long and very complete series already taken with the "Abney" lens, and similar photographs on three times the scale, by means of a negative enlarging lens by Dallmeyer.

2nd. Photographs of the surroundings of the Sun by means of a prism in front of the object-glass. (Prismatic camera.)

3rd. Photographs of the spectrum of the Corona by slit spectroscopes.

The West African Expedition was placed in charge of Professor Thorpe, F.R.S. Professor Thorpe, assisted by Mr. Gray and Mr. Forbes, undertook the determination of the photometric intensity of the coronal light by the method he used at the Solar Eclipse of 1886 in Granada. A complete and satisfactory series of observations was made.

Mr. A. Fowler undertook the prismatic camera observations, using a 6-inch telescope, lent by Mr. Lockyer, with a large prism in front of the object-glass. Mr. Fowler took six plates before and after totality, and fifteen during totality. The photographs are considered by Mr. Lockyer, at whose wish this investigation was made, to be of very great value.

Sergeant Kearney, R.E., had charge of the coronagraph.

With the Abney and Dallmeyer lenses and a double camera eleven pictures of the Corona were secured, which are of a most satisfactory character.

Captain E. H. Hills, R.E., undertook the slit spectroscopes, and obtained two excellent photographs.

Mr. A. Taylor and Mr. W. Shackleton formed the expedition to Brazil. The coronagraph was placed in charge of Mr. Taylor, as well as the slit spectroscopes, to be used if the necessary local help could be obtained. Twelve photographs of the solar Corona were obtained, of a similar character to those obtained in Africa, and directly comparable with them as regards exposure, density, and detail of the coronal structure. Most of those coronal plates have Captain Abney's density squares impressed upon them for determining the density of the photographic image. Two photographs with the slit spectroscopes were obtained.

Mr. Shackleton, with an arrangement somewhat similar to that employed by Mr. Fowler, took a large number of photographs; these are only less valuable than the African photographs in that the instrument employed was on a smaller scale.

The air at Fundium was hazy. At Pará-Curu the observations were made under particularly fortunate circumstances, as the Sun was clear of clouds only for a short time about the time of the eclipse.

Generally speaking, the results obtained are of a most satisfactory character. The photographs taken at each station provide a large amount of material to work upon, particularly those taken with the prismatic camera. From the distance apart of the two stations and the duplication of the work, a comparison may throw some light on the question of change of form and nature of the surroundings of the Sun during the interval between the observations. In this respect we may have the photographs taken at Chili to further extend this time interval.

The various members of the expeditions have enjoyed good health, and no one seems to have suffered injury from the excessive heat.

The Committee are under great obligations for much assistance given to the expeditions. The work of observation in Africa was made on French territory. The French Government did everything possible in granting a choice of sites, and M. Victor Allys, the French Administrator at Fundium, gave most valuable help.

The Admiralty gave us a gunboat to take the party up the Salum River and attend on them during the time this work lasted, and a cruiser brought the party from Bathurst to Grand Canary. The value of the help afforded by the Admiralty can be appreciated when it is known that without it this expedition could not have been sent.

From many other quarters most valuable aid has been received, and will be more fully acknowledged in the General Report.

The Motion of Σ 1819. By S. W. Burnham, M.A.

Since the first measures of this pair by Struve, in 1828, the companion has passed through an arc of nearly 90°. During this interval it has been frequently measured by most of the double star observers. It is always an easy pair, as the distance is never less than 1″, and the components are sensibly equal in magnitude. The only orbit of this pair was computed by Casey in 1882, using measures from 1828 to 1877 (*A. N.* 2421). Some of the measures made during this interval were omitted, but this could not materially affect the conclusion. He found a period of 340·1 years. Subsequently, Berberich challenged the correctness of this result (*A. N.* 2518), and showed that the measures could be well represented by rectilinear motion, and that therefore the relative change was probably due to proper motion. So far as one could judge alone by the residuals resulting from his comparison of the measures as a whole with a right line, a good *primâ facie* case was made; and if the claim had been simply that at this time, in consequence of the shortness of the arc and the errors of the observations, no ellipse could be drawn to represent these discordant measures, which would be more likely to be the correct orbit than any one of many others which could be substituted, there would be nothing further to be added until the observations cover a much longer time.

But when we consider all the circumstances, the proper motion of the system as a whole, the relative magnitudes, and particularly the distance between the components, and the measures, such as they are, there seems to be no reasonable doubt that these stars form a binary system. We may further consider that although the measures can be apparently well represented by rectilinear motion, still when the character as to accuracy of all such observations is taken into account, such argument has very little bearing upon the question. That these measures are many of them bad—inexcusably so—is obvious enough from a casual inspection; but they are no worse than the measures of all pairs of this class which cover a period of sixty years. If the measures which have been used in computing the orbits of any of the long-period binaries, where no question has been raised as to the character of the relative motion, were submitted to this test, it would be found in every instance that the motion could be substantially as well represented by a straight line. This will explain the enormous discrepancies in the periods of the same pair by different computers where the angular change is small. We have periods of *Castor* ranging from 250 to 1,000 years, of σ *Coronæ* from 195 to 845 years, and λ *Ophiuchi* from 89 to 370 years. Many other similar instances might be cited, but it is sufficiently evident that if two independent investigators should reach the

same result, it would be due to the accident of their treating discordant observations in the same manner. Anything from a circle to a straight line will represent the measures in nearly all of these small arcs, and the most laborious and thorough analytical investigation is not likely to give any better result than would be obtained in a moment's time by simply taking the angular motion as uniform throughout the apparent orbit. In this connection an examination of the widely differing results obtained of stars of the class under consideration, given in Gore's *Catalogue of Binary Stars*, will be instructive. There is no doubt whatever, in most instances at least, of the physical connection of these stars, but the data are wholly insufficient for the determination of the periods and other elements of the orbits. It is very questionable if it is worth while spending any time in the investigation of the orbit of any binary where the arc representing the angular motion is not at least 180°. Certainly in the majority of instances not even an approximate result can be obtained. If the measures were free from errors, then, of course, one ellipse, and only one, would represent them; but with the material we have, and particularly where it runs back nearly to the beginning of micrometrical work, a great variety of curves will satisfy the observed positions equally well, even when one-half of the orbit has been passed over. The fact is that the best-known orbits are those of double stars discovered in the last fifteen or twenty years.

In looking up the question of the motion of Σ 1819 it was necessary in the first instance to collect all the measures down to date. As these will be wanted in some future investigation, I give them here:—

Measures of Σ 1819.

Date.	P.	D.	n	
1828·35	88°·0	0″·86	2	Struve
1832·42	84·9	1·10	2	Struve
1836·43	76·1	1·13	4	Struve
1841·35	65·2	0·95	1	Mädler
·93	66·4	1·07	2	O. Struve
1842·40	63·2	0·87	3	Mädler
·81	60·5	1·08	3	Dawes
1843·24	62·8	...	7	Kaiser
·34	61·9	1·02	1	Dawes
·34	61·2	0·94	1	Mädler
1844·35	62·0	0·83	1	Mädler
1845·38	57·1	1·04	1	Mädler
1847·41	54·1	1·16	5	Mädler
1849·36	52·9	1·19	2	O. Struve
1851·29	49·6	1·27	5	Mädler
1852·39	46·1	1·02	1	Mädler

Date.	P.	D.	n	
	°	″		
1853·42	45·3	1·09	2	Mädler
1854·39	44·4	1·14	4	Mädler
1856·39	43·7	0·93	2	Secchi
·41	47·4	1·19	1	Mädler
1857·42	42·7	1·05	1	Mädler
·82	41·6	1·1	10	Dembowski
1858·38	38·2	1·0	1	Mädler
1859·45	39·4	1·00	1	Secchi
1863·01	32·3	1·29	11	Dembowski
1864·41	34·5	1·17	2	Secchi
1866·42	36·5	1·43	1	O. Struve
·49	30·5	1·21	8	Dembowski
1867·28	31·9	1·94	...	Talmage
·31	33·5	1·03	2	Searle
1868·18	34·1	0·88	1	Searle
1870·36	26·2	1·23	3	Gledhill
1871·31	26·1	1·35	3	Gledhill
·69	24·2	1·31	9	Dembowski
1872·38	24·8	1·19	2	Wilson & Seabroke
1873·32	25·3	1·28	2	Wilson & Seabroke
1874·41	23·2	1·33	1	Wilson & Seabroke
1875·36	21·6	1·47	4	Schiaparelli
·38	24·1	1·40	1	Wilson & Seabroke
1876·41	23·2	1·37	1	Wilson & Seabroke
·41	20·1	1·26	3	Hall
·59	19·9	1·18	5	Dembowski
1877·33	17·2	...	2	Doberck
·37	19·0	1·23	1	Plummer
1878·40	17·8	1·22	2	Doberck.
·42	20·4	1·38	2	Wilson & Seabroke
1879·40	18 6	1·49	4	Schiaparelli
·49	19·2	1·20	2	Wilson & Seabroke
1880·37	14·3	1·34	4	Hall
1881·39	15·7	1·26	4	Hall
·45	15·9	1·56	3	Schiaparelli
·46	15·1	1·45	1	Hough
1882·30	16·2	1·27	2	Doberck
·41	14·9	1·32	3	Hall
·45	17·2	1·60	4	Schiaparelli
1883·42	13·8	1·35	2	Hall

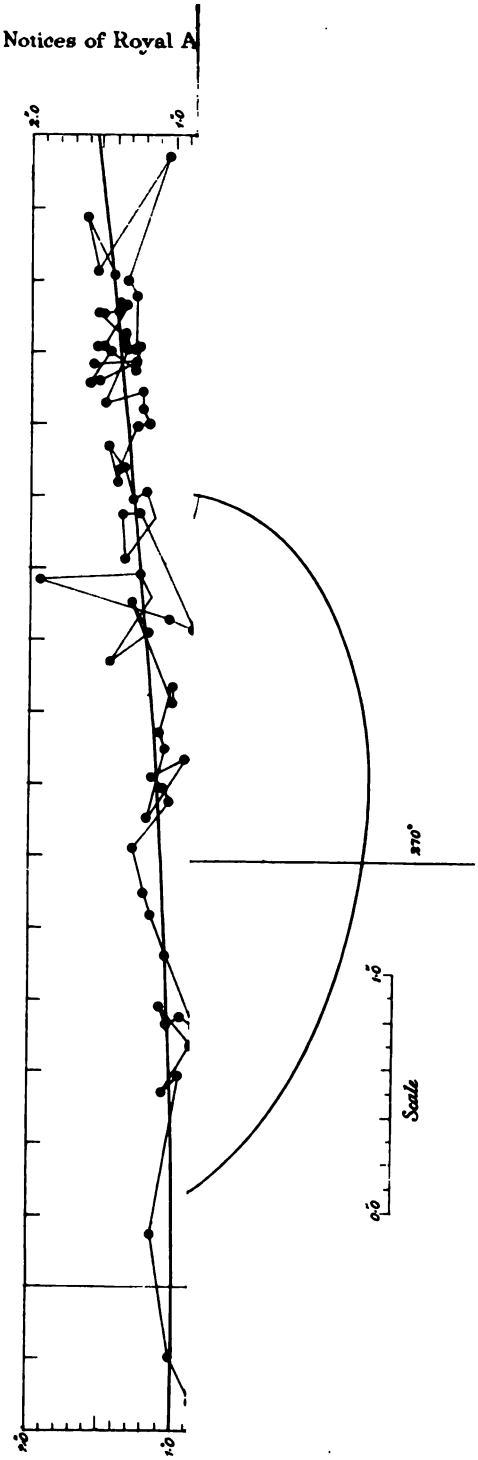


Fig. 2 Σ 1819

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Date.	P.	D.	n	
1853·42	45°·3	1″·09	2	Mädler
1854·39	44·4	1·14	4	Mädler
1856·39	43·7	0·93	2	Secchi
·41	47·4	1·19	1	Mädler
1857·42	42·7	1·05	1	Mädler
·82	41·6	1·1	10	Dembowski
1858·38	38·2	1·0	1	Mädler
1859·45	39·4	1·00	1	Secchi
1863·01	32·3	1·29	11	Dembowski
1864·41	34·5	1·17	2	Secchi
1866·42	36·5	1·43	1	O. Struve
·49	30·5	1·21	8	Dembowski
1867·28	31·9	1·94	...	Talmage
·31	33·5	1·03	2	Searle
1868·18	34·1	0·88	1	Searle
1870·36	26·2	1·23	3	Gledhill
1871·31	26·1	1·35	3	Gledhill
·69	24·2	1·31	9	Dembowski
1872·38	24·8	1·19	2	Wilson & Seabroke
1873·32	25·3	1·28	2	Wilson & Seabroke
1874·41	23·2	1·33	1	Wilson & Seabroke
1875·36	21·6	1·47	4	Schiaparelli
·38	24·1	1·40	1	Wilson & Seabroke
1876·41	23·2	1·37	1	Wilson & Seabroke
·41	20·1	1·26	3	Hall
·59	19·9	1·18	5	Dembowski
1877·33	17·2	...	2	Doberck
·37	19·0	1·23	1	Plummer
1878·40	17·8	1·22	2	Doberck
·42	20·4	1·38	2	Wilson & Seabroke
1879·40	18 6	1·49	4	Schiaparelli
·49	19·2	1·20	2	Wilson & Seabroke
1880·37	14·3	1·34	4	Hall
1881·39	15·7	1·26	4	Hall
·45	15·9	1·56	3	Schiaparelli
·46	15·1	1·45	1	Hough
1882·30	16·2	1·27	2	Doberck
·41	14·9	1·32	3	Hall
·45	17·2	1·60	4	Schiaparelli
1883·42	13·8	1·35	2	Hall

Fig. 2 Σ 1819

Stellenwood & C.° lith. London

Date.	P.	D.	n	
1883·46	14°·6	1″·53	5	Schiaparelli
·46	14·6	1·25	1	Seabroke
·85	17·0	1·52	7	Engelmann
1884·42	13·7	1·33	3	Hall
·45	14·7	1·49	5	Schiaparelli
1885·37	11·8	1·32	3	Hall
·41	11·4	1·39	2	Perrotin
·45	12·1	1·50	5	Schiaparelli
·52	12·0	...	2	Smith
1886·43	12·1	1·39	3	Hall
·47	12·2	1·54	2	Smith
1887·35	14·9	1·28	3	Tarrant
·38	11·1	1·28	4	Hall
·43	10·0	1·33	5	Schiaparelli
1888·39	8·0	...	1	Smith
1889·32	1·4	1·05	2	Highton
1890·45	9·1	1·53	2	Glasenapp
1891·46	5·7	1·62	2	Collins
·49	9·5	1·42	3	Maw

The discordances are large, and it is clear that we must in some way get a mean line which will represent as fairly as possible the path of the star as derived from all the measures. I know of no better way in this particular instance than that followed in the diagrams illustrating my paper on "Invisible Double Stars" (*Monthly Notices*, 1891 April), and I have accordingly laid down each one of these measures, when both angle and distance are given, on the diagram, plate 9, fig. 1, the angles being shown on the horizontal scales and the distances on the vertical scale. The consecutive measures are connected by lines, so that any one can be readily identified. The long curved line was then carefully drawn through these observed positions, so as to represent them as a whole as accurately as possible. The distances of points on this line at intervals of 5° were then taken from the diagram for the 85° represented by the observations, and laid down on the diagram, fig. 2, in the usual way from the central star. These seventeen positions are shown by the white circles. Then an ellipse was drawn which should pass through these several points as nearly as possible.

As a further check, and illustration of the character of the motion, I have plotted from the central star the observed positions for each year represented by measures. These are shown by the black circles outside the ellipse. Where more than one observer has measured it in a single year, a simple mean has been taken of all the measures. Only two observations have been omitted from the means, and both because the distances

were manifestly absurd. The angles and distances of the several positions were laid down with all possible accuracy, but in order to avoid confusing the two sets, the scale of distances for the observed positions is one and one-half time the scale used in laying down the first positions. The divided scale of 1″·0 shown on the diagram has reference to the white circles.

Certainly these positions appear to show orbital motion beyond all question. If there is any doubt in regard to this, then it follows as a matter of course that no binary system is positively known as such, where the period is more than 300 years.

The ellipse shown on fig. 2 gives a period of 310 years. This may or may not be somewhere near the correct time. A variety of curves may be passed through these corrected positions, where the arc is only 90°, and represent them equally well. The most that can be said of this is, that the period will not be less than 300 years, while it may be considerably longer. Casey's period of 340 years can be made to suit these positions, but in other respects it would differ, and particularly in the eccentricity. It will be observed that the real orbit shown on the diagram is circular, while the computed orbit has an eccentricity of 0·30.

In the Albany Zone Observations (*Astronomical Journal*, No. 200) Boss gives the annual proper motion of the mean of the two components as 0″·184 in the direction of 277°·2. Assuming this to be the movement of the principal star, then if the relative change is due to proper motion, the companion would have an annual motion of 0″·197 in the direction of 283°.

Chicago:
May 10.

The Orbit of 40 *Eridani*, Σ 518. By S. W. Burnham, M.A.

The double companion to 40 *Eridani* was discovered by Herschel in 1783. It was next observed by Struve in 1825, but was too difficult to measure. The measures of precision really commence with the observations of O. Struve in 1851. Since that time it has been looked after by the various double star observers, and the arc of nearly 60°, through which the small star has passed in the last forty years, is very well defined, and the measures as a whole appear to be fairly satisfactory. The mean angular change has been about one degree and a half per year, but it is obvious that the apparent ellipse is a very elongated one, and therefore the average motion for a complete revolution will be a much smaller quantity.

Though the period is long, this is an interesting binary from the large proper motion of the system. Only four stars in the northern hemisphere have a larger proper motion. This is common to the principal star, and to the binary companion which is more than 80″ distant. Hall finds a parallax for A of 0″·22, so that the system is comparatively near the Earth.

The only orbit of BC is by Gore (*Monthly Notices*, 1886 March), who used the measures down to, and including, 1883. He found a period of 139·0 years. Since that time additional measures have been made which are not well represented by the ellipse, and it is evident that this provisional orbit is not the best which can now be made.

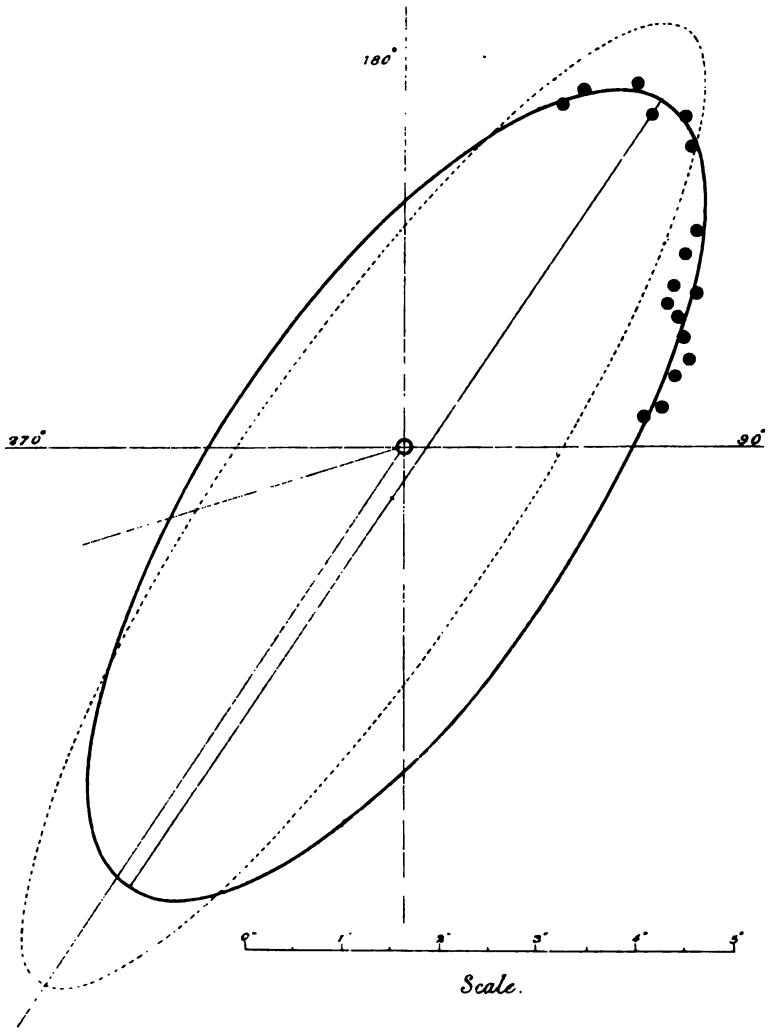
I have collected from original sources all the observations, and give them in chronological order:—

	Date.	P.	D.	n	
1	1783·13	326°·7	Cl. II.	1	Herschel
2	1825·12	287	...	1	Struve
3	1851·06	159·9	3″ ±	1	Dawes
	·22	155·8	3·91	4	O. Struve
4	1855·06	154·0	4·14	6	O. Struve
5	1864·85	147·6	4·45	2	Winnecke
	1865·90	144·0	4·26	2	O. Struve
7	1869·10	140·4	4·46	1	O. Struve
8	1873·85	137·0	4·27	4	O. Struve
9	1877·84	128·2	3·92	6	Burnham
	·84	127·5	3·36	3	Cincinnati
	·95	126·4	3·94	4	Dembowski
10	1879·05	125·4	3·49	4	Burnham
	·11	122·9	...	1	Cincinnati
	·18	125·0	3·51	2	Hall
11	1879·75	120·0	3·29	1	Cincinnati
	80·09	121·3	3·28	5	Burnham
	80·95	122·0	3·16	5	Burnham
12	1881·84	119·0	3·53	6	Burnham
	2·12	118·1	3·24	2	Hall
13	1883·00	119·2	3·07	2	Burnham
14	1883·80	115·8	3·10	2	Hall
1	1886·00	112·2	3·22	2	Leavenworth
	·09	112·2	3·00	6	Hall
	·92	111·0	3·01	3	Tarrant
16	1888·12	107·7	3·04	5	Hall
17	1888·84	106·8	2·94	3	Burnham
	8·87	105·0	2·81	3	Tarrant
	9·12	103·5	2·79	4	Hall
18	1890·73	100·0	2·68	4	Burnham
	1·05	98·5	2·65	5	Hall
19	1891·78	97·4	2·48	4	Burnham

The two angles of Herschel and Struve, and the seventeen positions derived from the measures, as shown above, are accurately laid down on the diagram, plate 10. When more than one set of measures is used, as indicated by the brackets and corresponding marginal numbers, a simple mean is taken.

Now it is obvious that it is impossible to obtain by any method the real or apparent orbit of this pair from an arc of only 60°. A great variety of ellipses could be made which would represent these positions equally well, and which would differ widely from each other in every element. The angles of Herschel and Struve are the only means we have of deciding upon the particular form of ellipse which shall be taken to represent the orbit. In doing this it is necessary to carefully weigh the probable relative values of these angles, because it is certain that if we put all of the observations on the same footing, and distribute the errors as equally as possible over the later accurate measures and the somewhat uncertain early angles, the result will not be reliable. In 1783, when Herschel discovered this pair, it must have been a very easy object, as from the estimated distance he placed it in Class II. (4″ to 8″). He appears to have made only a single measure of the angle, but in a pair as wide as this, that should give it within a few degrees at most of the true value, even from a rough setting of the wires. Therefore we may assume that the distance was not less than 4″, and that the angle was not far from 326°. It is unfortunate that he did not make some attempt to measure the distance. Even a careful estimate at that time would be of great value now, since the errors of estimation should not much exceed 1″ in a pair of this kind.

In the position for 1825 there is much more uncertainty. This is about the only star of the class in Struve's *Mensuræ Micrometricæ* which he was unable to measure. It is not given in its proper place as a close pair in this work. It is mentioned in the section where the distant star is treated (p. 275), and again in that part of the introduction which relates to proper motion (p. cxi). It must have been seen with extreme difficulty, as otherwise it would have been observed in the usual way, and given its proper place under his Class II. in the Catalogue. The angle which he gives seems to have been regarded heretofore as some sort of measure, since one would hardly attempt to estimate a position-angle, even of the easiest pair of stars, so closely as to give it 287°. When we examine *Mensuræ Micrometricæ* carefully the explanation is very obvious. We find that this angle not only does not purport to be from a measure, but is not even an independent estimate. At this time Struve measured the angle of B from the large star, and obtained 107°. He evidently regarded C as being very nearly in line with AB, and consequently called the angle 287°. Therefore I think that all we are justified in inferring from this observation is that in 1825 the companion



40 Eridani. Σ518.

Vincent Brooks & Co. Lith. London.

was somewhere on the preceding side, and that the pair was close, and excessively difficult with the Dorpat telescope.

In drawing the ellipse to represent the apparent orbit there are two conditions to be met. First, it must represent as accurately as possible the observed positions from 1851 to 1892, and in this respect nothing must be sacrificed to make it conform to the earlier position-angles; and, secondly, the eccentricity and the length and direction of the major axis must be such that the areas of 1783 to 1851, and 1851 to 1892 are, as nearly as possible, proportional to the times. The uncertainty of the angle of 1825 is so great, it should not be used in determining the form of the ellipse. The result is far more likely to be correct when the other observations are depended upon.

Gore's orbit is shown on the diagram by the dotted ellipse. He has evidently made it conform to Struve's angle in 1825, since the error of that angle is only 5°·3, but in doing so it was necessary to sacrifice to some extent the measured positions of 1851 to 1883. It is obvious that this ellipse does not represent the distances at all satisfactorily. Ten of the distance measures require corrections of from 0″·70 to 0″·93. It would seem that measures by these observers, of a pair of this kind, should not have these large errors.

With the considerations in view which I have mentioned, I have drawn, after repeated trials, the ellipse shown on the diagram. It will be seen that it represents well all of the measured positions. The variations in distance are certainly not larger than the probable errors of the best observers, and the angles are correspondingly accurate. In the following table will be found the corrections to be applied to the observed distances. These values will not be sensibly affected by the small changes in the angles.

1851·22	0″·00	1881·98	−0″·03
1855·06	−0·10	1883·00	+0·30
1864·85	−0·10	1885·80	+0·08
1865·90	+0·15	1886·34	−0·08
1869·10	−0·07	1888·12	−0·22
1873·85	+0·03	1888·94	−0·12
1877·88	+0·08	1890·89	−0·10
1879·11	+0·20	1891·78	0·00
1880·26	+0·24		

According to this orbit the angle at the time of Herschel's observation in 1783 was 324°·8, and the distance 5″·35. At the date of Struve's examination the angle would be 244°·7, and the distance 1″·70. Under the circumstances this variation in the angle is not surprising. If the small star had been seen with any certainty, it would have been measured like other difficult pairs in the *Mensuræ Micrometricæ*.

From this ellipse we get the following elements :—

P = 179·7 years.	i = 69°·4
T = 1843·7	☊ = 146°·2
e = 0·142	λ = 313°·9
a = 6″·25	ϖ = 166°·7

According to this orbit the distance will slowly diminish until it is little more than 2″, and then gradually increase again until the maximum of nearly 5″·4 is reached, when one complete revolution will have been described since the observation of Herschel. It happens that he discovered this pair when the distance was the greatest, and Struve observed it when the distance was minimum.

I hope observers with large apertures will regularly measure this system. The angular motion should steadily increase for some years.

Chicago :
May 24.

The Orbit of Sirius. By S. W. Burnham, M.A.

In *Monthly Notices* for 1891 April (vol. li. p. 378) I gave a list of all the measures of the companion of *Sirius*, and a diagram showing the ellipse which seemed to represent the observations as a whole as well as this could be done. I did not undertake to give from this ellipse the elements of the real orbit, for the reason that this and all other orbits of *Sirius*, down to this time, are necessarily only provisional, and roughly approximate at the best, and their interest will cease as soon as the companion can be measured again. It will then be in the third quadrant, or about 180° of position-angle, and a good set of measures at that time should fix the movement of the companion with considerable certainty. For the present all we need is the apparent orbit, in order to know about where to look for the small star. In the paper referred to I gave the period according to this orbit as fifty-three years. Dr. T. J. J. See has recently examined the original diagram, and has called my attention to an error in this quantity. I have gone over the matter carefully, and find that in some way I have made a considerable error in the period as published in my paper.

In the course of this re-examination I have deduced the remaining elements from this ellipse as follows :—

P = 51·97 years.	i = 50°·8
T = 1893·5	☊ = 40°·3
e = 0·568	λ = 135°·4
a = 8″·31	Per. (app.) = 253°·0

Whatever the final orbit may be, I do not think any other can be made at this time to better represent the observations. It will be seen that this differs from Auwers' orbit of the theoretical star (*Ast. Nach.* 3084) by 2·57 years in the period. In some of the other elements the difference is a little more.

Chicago:
May 30.

Probable Errors of Greenwich Observations of Close Circumpolar Stars. By T. Lewis.

In the *Monthly Notices* for 1889 April, Mr. Downing gives the probable error of a result for R.A. as obtained with the Greenwich transit circle at different zenith distances, and for the four close circumpolar stars. He finds for λ *Ursæ Minoris*, δ *Ursæ Minoris*, and *Cephei* 51, whether above or below pole, sensibly the same result in equatorial arc, viz., $\pm^{s}\cdot030$; but for *Polaris* the result is $\pm^{s}\cdot020$.

This probable error includes not only the errors of observation, but those of the determinations of instrumental position. In nearly all cases where these stars have been kept "for place," the azimuthal error has been deduced from consecutive transits of *Polaris*, which doubtless accounts for the smaller value of the resulting probable error in the case of *Polaris*.

The results obtained by Mr. Downing for the circumpolars relate to eye and ear observations, whether over the fixed galvanic wires or over the same wire set to different readings of the transit micrometer. From 1889 January 1 these stars have been observed chronographically by moving the centre wire with the transit micrometer until the star is accurately bisected, and recording the instant of bisection on the chronograph with the left hand. Moreover, the list of circumpolar stars under constant observation at Greenwich has been increased (since 1888 September) by the addition of all those whose ephemerides are given in the *Connaissance des Temps*, or M. Lœwy's Annual Tables.

The following additional information with regard to the observation of close circumpolars is therefore of interest:—

(1) *The errors of bisection* and *of eye and ear estimates.* The separate bisections, or estimates of transits, were reduced to the centre wire and compared with the mean result. Observations of the close circumpolar stars, made both before and after 1889 January 1, were considered, and the results for each of the four regular observers kept separate. The probable errors are reduced to the equator.

Observer.	λ Ursæ Min. E. and E.	λ Ursæ Min. Chron.	Polaris. E. and E.	Polaris. Chron.	Cephei 51. E. and E.	Cephei 51. Chron.	δ Ursæ Min. E. and E.	δ Ursæ Min. Chron.
	s	s	s	s	s	s	s	s
A. D.	±·013	±·016	±·011	±·019	±·023	±·021	±·024	±·018
T.	±·015	±·019	±·015	±·023	±·020	±·026	±·021	±·024
L.	±·010	±·017	±·013	±·016	±·017	±·022	±·023	±·020
H.	±·016	±·023	±·016	±·019	±·020	±·030	±·030	±·027
Mean	±·014	±·019	±·014	±·019	±·020	±·024	±·027	±·022

The probable error of an estimate is thus smaller than that of a bisection, which would seem to point to the E. and E. method being the more accurate for stars very near the pole. It is to be remarked, however, that in the eye and ear method the readings of the micrometer screw, and consequently the times of transit, were separated by equal intervals, and there might be a tendency to equalise the recorded intervals. In the chronographic method the intervals are quite unknown, and thus the observations are entirely independent. This, therefore, may readily be one of the cases where a smaller probable error indicates an inferior observation.

It is further to be remarked that the error of bisection increases with the N.P.D. To bring this out more prominently, other circumpolar stars were examined, and also a large number further from the pole. Some differences are shown by the several observers, but a detailed examination of these peculiarities is not made on this occasion.

TABLE II.

Star.	N.P.D.	P.E.	Group. N.P.D.	P.E. Above Pole.	P.E. Below Pole.
	° ′	s	° °	s	s
λ Ursæ Minoris	1·2	±·019	5–10	±·023	±·025
Groombridge 1119	1·2	±·018	10–15	·034	·035
Polaris	1·20	±·019	15–20	·039	·038
Bradley 1672	1·41	±·020	20–25	·040	·042
Groombridge 2283	2·20	±·019	25–30	·042	·044
Cephei 51	2·47	±·024	30–40	·049	·045
Bradley 3147	3·19	±·024	40–50	·054	·055
δ Ursæ Minoris	3·23	±·022			
2 Ursæ Minoris	4·20	±·028			
Bradley 2993	4·27	±·032			

The error is thus sensibly the same above and below pole to considerable polar distances, but the increase with distance from the pole is very marked up to 50°, when, from a discussion made by Mr. E. Dunkin, it would appear to remain practically constant. Here the chronographic method clearly showed to advantage.

Mr. Dunkin's results in 1864* :—

N.P.D.	Probable Error of one Wire E. and E.	Chronographic.
° °	s	s
60–70	± ·089	± ·052
70–80	·082	·052
80–90	·073	·051
90–100	·070	·051
100	·070	·050

(2) As regards *the error of a result for R.A.*, there is, of course, nothing to add to Mr. Downing's results, except in the case of the four close circumpolar stars. Assuming $\pm^{s}\cdot030$ as the P.E. of a resulting R.A. for λ *Ursæ Minoris*, *Cephei* 51 and δ *Ursæ Minoris*, and $\pm^{s}\cdot020$ for *Polaris* from the E. and E. method, we should get theoretically for the P.E. of result for R.A. by the chronographic method:

	s
λ Ursæ Minoris and Cephei 51	± ·031
δ Ursæ Minoris	± ·029
Polaris	± ·021

The actual P.E.'s from the observations in 1889 and 1890 (chronographic method) are :—

	s
Cephei 51	± ·031
δ Ursæ Minoris	± ·0295
λ Ursæ Minoris	± ·026
Polaris	± ·021

Agreeing well with the indirect method of combining error of bisection and instrumental error, except in the case of λ *Ursæ Minoris*.

* *Monthly Notices*, vol. xxiv., p. 154.

Observations of the Satellites of Saturn in 1893.

By the Rev. Alex. Freeman, M.A.

The observations were made with a refractor equatorially mounted and having an aperture of 6½ inches; the focal length is nearly thirteen times the aperture. The power used was 116, being found most suitable for the purpose. By the term conjunction is meant a coincidence of position on a line normal to the ring-axis of *Saturn*. Results only are given for the moment of conjunction, though divergence from conjunction within 5^m before and after the actual conjunction was usually also noted. Greenwich Mean Time is employed.

February $3^d\ 12^h\ 14^m{\cdot}7$, *Enceladus* seen very near west elongation, due $12^h{\cdot}35$.

February $3^d\ 13^h\ 17^m{\cdot}4$, *Enceladus* was co-linear with *Tethys* and *Dione*, both south of line of ring-axis.

February $3^d\ 13^h\ 38^m{\cdot}0$, *Rhea* and *Tethys* very nearly in conjunction normally to ring-axis, and about one equatorial diameter of ♄ preceding west end of ring. The calculated distances of Rh. and Te. from polar axis of ♄ are $44''{\cdot}66$ and $44''{\cdot}46$ for the observed time.

February $14^d\ 12^h\ 1^m$, *Rhea* very closely followed north part of ball of ♄, and was not yet up to the east tangent at end of *Saturn's* equator.

March $15^d\ 10^h\ 40^m$, *Tethys* not yet up to west end of ring, cloudy soon after. (Te. θ, $10^h{\cdot}7$, Marth.)

March $19^d\ 11^h\ 18^m$, *Tethys* half-ansa length from the ball of ♄ east. Within $0''{\cdot}9$ of tabular place.

April $12^d\ 11^h\ 45^m{\cdot}2$, *Dione*, south preceding, opposite middle point of line joining inner and outer ring-ends.

April $17^d\ 11^h\ 5^m{\cdot}7$, *Tethys* not quite up to east end of ring. $11^h\ 8^m{\cdot}2$, *Tethys* almost quite up. It then became cloudy. (Te. ζ, $11^h{\cdot}2$, Marth.)

April $20^d\ 9^h\ 53^m{\cdot}5$, *Dione* now fully up to east ring-end, south. (Di. ζ, $10^h{\cdot}1$, Marth.)

April $23^d\ 10^h\ 44^m$, *Dione* was in conjunction with west end of Cassini division, south of ring.

April $23^d\ 11^h\ 19^m$, *Dione* in conjunction with west end of ring, south. (Di. η, $11^h{\cdot}4$, Marth.)

April $30^d\ 10^h\ 49^m{\cdot}8$, *Titan* is now on the south polar axis of *Saturn* produced. The distance between the limbs of

Titan and *Saturn* equal to the polar radius of *Saturn*. The Washington N.A. gives inferior conjunction south at $11^h\ 14^m{\cdot}2$ G.M.T.

April $30^d\ 10^h\ 55^m$, *Tethys*, *Dione*, and *Iapetus* nearly co-linear, *Dione* perhaps a little east of the line.

May $5^d\ 9^h\ 23^m{\cdot}5$, *Tethys* just up to west ring-end north. $9^h\ 33^m{\cdot}5$ decidedly past. (Te. θ, $9^h{\cdot}6$, Marth.)

May $5^d\ 11^h\ 7^m{\cdot}5$, *Dione* just up to west ring-end north. (Di. θ, $11^h{\cdot}2$, Marth.)

May $9^d\ 11^h\ 19^m$, *Tethys* very little beyond east ring-end north. (Te, ϵ, $11^h{\cdot}1$, Marth.)

May $10^d\ 10^h\ 17^m$, *Tethys* had a little passed west ring-end south. (Te. η, $9^h{\cdot}7$, Marth.)

May $16^d\ 9^h\ 13^m{\cdot}5$, *Titan* had passed the south polar axis produced by one-fifth of the equatorial radius of ♄. He was distant from the south pole at least the polar radius of ♄. Washington N.A. gave inferior conjunction south at $9^h{\cdot}23$ G.M.T. (An observer at Brighton with $10\frac{1}{2}$-inch reflector made *Titan* to be on the polar axis at $8^h\ 55^m$.)

May $16^d\ 9^h\ 54^m$, *Dione* in conjunction with west ring-end north. (Di. θ, $9^h{\cdot}9$, Marth.)

May $27^d\ 8^h\ 34^m{\cdot}4$, *Dione* in conjunction with west ring-end north. (Di. θ, $8^h{\cdot}6$, Marth.)

May $27^d\ 9^h\ 27^m{\cdot}4$, *Tethys* in conjunction with Cassini division at west end, south.

May $27^d\ 9^h\ 38^m{\cdot}9$, *Tethys* in conjunction with west ring-end south. (Te. η, $9^h{\cdot}5$, Marth.)

June $2^d\ 8^h\ 53^m$, *Rhea* in conjunction with *Tethys* on the west of *Saturn*. The distance of the centres of the satellites about equal to polar radius of ♄. By Marth's ephemeris, *Rhea* $44''{\cdot}29$ west and $7''{\cdot}01$ north, whilst *Tethys* $44''{\cdot}38$ west and $0''{\cdot}27$ south. Polar radius of *Saturn* is $8''{\cdot}02$. The agreement in distance from the polar axis of ♄ is within $0''{\cdot}1$.

Marston Rectory, Sittingbourne:
1893 *June* 5.

Observations of Comet 1892 d (Brooks) made at the Royal Observatory, Cape of Good Hope.

(*Communicated by D. Gill, LL.D., F.R.S., H.M. Astronomer.*)

1893.	Cape Mean Time.	Comet−Star. Δ α.	Δ δ.	No. of Comps.	Observer.	Comet's App. R.A.	Log. ($p \times \Delta$).	Comet's App. Dec.	Log. ($p \times \Delta$).	Reduction to App. Place.	Comp. Star No.
	h m s	m s	′ ″			h m s		° ′ ″		s ″	
Jan. 16	14 59 51·2	−1 25·21	+2 55·8	9-8	F.	15 42 43·32	9·8014*n*	−41 55 31·6	0·3625*n*	−1·66 +4·1	1
18	15 3 20·9	−3 9·37	+0 54·1	6-8	F.	15 52 3·89	9·8005*n*	−42 4 28·3	0·3477*n*	−1·63 +3·4	2
23	14 46 55·9	−0 49·06	+1 8 1	12-12	F.	16 14 9·50	9·8113*n*	−42 14 27·0	0·4190*n*	−1·54 +2·2	3
24	14 49 26·6	−1 17·78	−1 8·7	12-12	F.	16 18 23·45	9·8104*n*	−42 14 33·6	0·4110*n*	−1·53 +1·9	4
28	14 56 34·5	−2 16·48	+1 39·3	12-8	F.	16 34 36·80	9·8068*n*	−42 9 39·9	0·3883*n*	−1·45 +0·9	5
30	14 46 35·9	−0 45·17	+3 45·8	12 8	F.	16 42 15·92	9·8107*n*	−42 4 26·1	0·4237*n*	−1·39 +0·5	6
Feb. 16	14 59 48·4	+2 0 64	−4 0·4	12-8	F.	17 36 44·85	9·7872*n*	−40 28 26·7	0 3547*n*	−0·93 −2·2	7
18	14 52 55·5	+1 11·91	−1 54·0	12-8	F.	17 41 55·59	9·7883*n*	−40 13 17·9	0·3740*n*	−0·87 −2·4	8
19	14 44 59 2	+1 43·91	−2 15·7	12-8	F.	17 44 25·19	9·7902*n*	−40 5 36·5	0·3993*n*	−0·84 −2·5	9
20	14 52 8·7	−2 29·21	−2 44·9	12-8	F.	17 46 52·21	9·7848*n*	−39 57 41·5	0·3701*n*	−0·83 −2·7	10
21	14 44 7 8	−0 42·47	−0 12·2	12-8	F.	17 49 14·62	9·7876*n*	−39 49 45·6	0·3964*n*	−0·79 −2·7	11
22	14 44 15·4	−1 30·56	−2 9·8	12-8	F.	17 51 34·15	9·7859*n*	−39 41 40·2	0·3915*n*	−0·77 −2·8	12
Mar. 16	14 54 19·8	−1 49·96	−1 45·2	11-8	F.	...	9·7188*n*	...	0·2248*n*	−0·09 −3·8	13
17	14 50 10·4	+3 13·46	+1 1·3	12-8	F.	...	9·7190*n*	...	0·2358*n*	−0·03 −3·8	14
18	14 41 40 0	−1 8·35	+1 10·5	12-8	F.	...	9·7245*n*	...	0·2610*n*	−0·02 −3·8	15
22	14 54 54·0	−2 29·68	+0 30·3	12-8	F.	18 34 39·78	9·6894*n*	−35 44 21·2	0·1691*n*	+0·11 −3·9	16
25	14 49 42·0	+1 31·33	−4 0·0	12-8	F.	18 36 53·92	9·6810*n*	−35 19 22·8	0·1635*n*	+0·23 −4·0	17
26	14 52 11·6	+2 10·06	+4 16·6	12-8	F.	18 37 32·68	9·6719*n*	−35 11 6·2	0·1418*n*	+0·26 −4·0	17
Apr. 14	14 8 36·1	+0 31·84	−0 53·3	12-8	F.	...	9·6134*n*	...	0·1225*n*	+0·91 −4·2	18
17	14 16 33·4	+0 42·38	+2 53·8	12-8	F.	...	9·5657*n*	...	0·0500*n*	+1·03 −4·3	19
20	13 45 48·2	−0 25·09	−3 16·3	12-8	F.	18 38 19·64	9·5999*n*	−31 52 7·2	0·1329*n*	+1·14 −4·5	20
23	13 10 50·3	−1 12·27	+1 46·6	12 8	F.	18 30 29·87	9·6282*n*	−31 25 3 2	0·2079*n*	+1·26 −4·7	21

Adopted Mean Places of Comparison Stars.

Comp. Star No.	R.A. 1893·0. h m s	Dec. 1893·0. ° ′ ″	Authority.
1	15 44 10·19	−41 58 31·5	C.Z. XV. 3020.
2	15 55 14·89	−42 5 25·8	Equat. diff. from *a*.
a	16 4 53·29	−42 5 45·1	A.G.C. 21923.
3	16 15 0·10	−42 15 37·3	One Equat. diff. from *b*.
b	16 11 50·86	−42 24 40·5	A.G.C. 22082, Cape (1880).
4	16 19 42·76	−42 13 26·8	C.Z. XVI. 1303.
5	16 36 54·73	−42 11 18·3	C.Z. XVI. 2491.
6	16 43 2·48	−42 8 12·4	Equat. diff. from *c*.
c	16 46 26·78	−42 11 0·0	A.G.C., Cape (1880) and (1885).
7	17 34 45·14	−40 24 24·2	A.G.C. 23959.
8	17 40 44·55	−40 11 21·5	Equat. diff. from *d*.
d	17 40 6·10	−40 5 5·3	A.G.C. 24107, Cape (1885).
9	17 42 42·12	−40 3 18·4	A.G.C. 24182, Cape (1880)
10	17 49 22·25	−39 54 53·9	A.G.C. 24328.
11	17 49 57·88	−39 49 30·7	C.Z. XVII. 3294.
12	17 53 5·48	−39 39 27·6	A.G.C. 24431.
13	18 31 (22)	−36 37	9¾ mag. = *e* { −2ᵐ 17ˢ·98 ; +3′ 15″·1.
e	18 33 (40)	−36 40	8½ mag.
14	18 27 (22)	−36 30	8½ mag.
15	18 32 (50)	−36 23	8 mag.
16	18 37 9·35	−35 44 47·6	A.G.C. 25565, Cape (1880).
17	18 35 22·36	−35 15 18·8	A.G.C. 25523.
18	18 41 (21)	−32 40	9½ mag. = *f* { −0ᵐ 25ˢ·10 ; +2′ 28″·0.
f	18 41 (46)	−32 42	8½ mag.
19	18 39 (6)	−32 20	9 mag.
20	18 38 43·59	−31 48 46·4	Equat. diff. from *g*.
g	18 40 15·99	−31 51 12·0	A.G.C. 25650.
21	18 31 40·88	−31 26 45·1	C.Z. XVIII. 1807.

Notes.

January 16, 18.—Very bad definition; comet very diffused.
February 19.—Comet bears as bright a wire in observing as a 10-mag. star.
April 14.—Comet faint, and a small star near it was troublesome.
April 23.—Comet near two stars; faint and difficult.

Ephemeris of the Fifth Satellite of Jupiter, 1893. By A. Marth.

Greenwich Noon. 1893.		P+90°	*a*	*b*	*l*−L.	Approx. Greenwich Times of greatest elongations.	
		°	″	″	°	h m	h m
Aug.	4	76·87	48″·37	+2″·64	292·14	17 12 E	23 11 W
	6	76·97	48·65	2·66	297·29	17 2 „	23 0 „
	8	77·07	48·93	2·68	302·44	16 51 „	22 50 „
	10	77·17	49·22	2·70	307·61	16 41 „	22 40 „
	12	77·26	49·51	2·72	312·79	16 31 „	22 29 „
	14	77·35	49·80	2·74	317·98	16 20 „	22 19 „
	16	77·43	50·10	2·76	323·18	16 10 „	22 9 „
	18	77·51	50·41	2·78	328·39	16 0 „	21 58 „
	20	77·59	50·72	2·80	333·61	15 49 „	21 48 „
	22	77·66	51·04	2·83	338·85	15 39 „	21 38 „
	24	77·73	51·36	2·85	344·09	15 28 „	21 27 „
	26	77·80	51·68	2·87	349·34	15 18 „	21 17 „
	28	77·86	52·00	2·89	354·61	15 7 „	21 6 „
	30	77·91	52·33	2·91	359·89	14 57 „	20 56 „
Sept.	1	77·96	52·67	2·94	5·18	14 46 „	20 45 „
	3	78·01	53·00	2·96	10·48	14 36 „	20 34 „
	5	78·05	53·34	2·98	15·80	14 25 „	20 24 „
	7	78·08	53·68	3·00	21·12	14 15 „	20 14 „
	9	78·11	54·02	3·03	26·46	14 4 „	20 3 „
	11	78·14	54·36	3·05	31·81	13 53 „	19 52 „
	13	78·16	54·70	3·07	37·17	13 43 „	19 41 „
	15	78·17	55·05	3·10	42·54	13 32 „	19 31 „
	17	78·18	55·39	3·12	47·93	13 21 „	19 20 „
	19	78·19	55·73	3·14	53·32	13 10 „	19 9 „
	21	78·19	56·07	3·17	58·73	13 0 „	18 58 „
	23	78·18	56·41	3·19	64·15	12 49 „	18 47 „
	25	78·17	56·74	3·21	69·58	12 38 „	18 37 „
	27	78·15	57·07	3·23	75·02	12 27 „	18 26 „
	29	78·13	57·40	3·26	80·47	12 16 „	18 15 „
Oct.	1	78·10	57·72	3·28	85·94	12 5 „	18 4 W
	3	78·05	58·04	3·30	91·41	11 54 „	23 52 E
	5	78·03	58·35	3·32	96·89	11 44 „	23 41 „
	7	77·98	58·66	3·34	102·39	11 33 „	23 31 „
	9	77·93	58·96	3·36	107·89	11 22 „	23 20 „
	11	77·88	59·24	3·37	113·40	11 11 „	23 9 „
	13	77·82	59.52	+3·39	118·92	11 0 E	22 58 E

Greenwich Noon. 1893.		P+90°	*a*	*b*	*l*−L.	Approx. Greenwich Times of greatest elongations.	
		°	″	″	°	h m	h m
Oct.	15	77·76	59·79	+3·41	124·45	10 49 E	22 47 E
	17	77·69	60·05	3·42	129·99	10 38 „	22 35 „
	19	77·62	60·29	3·44	135·53	10 27 „	22 24 „
	21	77·54	60·53	3·45	141·08	10 15 „	22 13 „
	23	77·46	60·75	3·46	146·63	10 4 „	22 2 „
	25	77·38	60·95	3·47	152·19	9 53 „	21 51 „
	27	77·29	61·14	3·48	157·76	9 42 „	21 40 „
	29	77·20	61·32	3·49	163·33	9 31 „	21 29 „
	31	77·11	61·48	3·50	168·90	9 20 „	21 18 „
Nov.	2	77·02	61·62	3·51	174·47	9 9 „	21 7 „
	4	76·92	61·75	3·51	180·05	8 58 „	20 56 „
	6	76·82	61·86	3·51	185·63	8 47 „	20 45 „
	8	76·72	61·95	3·52	191·20	8 36 „	20 33 „
	10	76·62	62·02	3·52	196·78	8 24 „	20 22 „
	12	76·52	62·07	3·51	202·35	8 13 „	20 11 „
	14	76·41	62·11	3·51	207·92	8 2 „	20 0 „
	16	76 31	62·12	3·51	213·49	7 51 „	19 49 „
	18	76·20	62·11	3·50	219·05	7 40 „	19 38 „
	20	76·10	62·09	3·49	224·60	7 29 „	19 27 „
	22	76·00	62·05	3·48	230·15	7 18 „	19 16 „
	24	75·90	61·98	3·47	235·70	7 7 „	19 5 „
	26	75·80	61·90	3·46	241·23	6 56 „	18 53 „
	28	75·70	61·80	3·45	246·76	6 45 „	18 42 „
	30	75·60	61·68	3·43	252·28	6 34 E	18 31 „
Dec.	2	75·51	61·55	3·42	257·78	12 22 W	18 20 „
	4	75·42	61·39	3·40	263·28	12 11 „	18 9 „
	6	75·33	61·22	3·38	268·76	12 0 „	17 58 „
	8	75·24	61·03	3·36	274·24	11 49 „	17 47 „
	10	75·16	60·83	3·34	279·70	11 38 „	17 37 „
	12	75·08	60·61	3·32	285·14	11 27 „	17 26 „
	14	75·00	60·38	3·30	290·57	11 16 „	17 15 „
	16	74·93	60·13	3·27	295·99	11 6 „	17 4 „
	18	74·86	59·87	3·25	301·39	10 55 „	16 53 „
	20	74·80	59·60	3·22	306·78	10 44 „	16 43 „
	22	74·74	59·32	3·20	312·15	10 33 „	16 32 „
	24	74 68	59·02	3·17	317·51	10 23 „	16 21 „
	26	74·63	58·72	3·14	322·85	10 12 „	16 11 „
	28	74·59	58·71	3·12	328·17	10 1 „	16 0 „
	30	74·55	58·09	+3·09	333·48	9 51 W	15 50 E

Greenwich Noon. 1894.		P+90°	*a*	*b*	*l*−L	Approx. Greenwich Times of greatest elongations.	
		°	″	′	°	h m	h m
Jan.	1	74·51	57·76	+3·07	338·77	9 40W	15 39 E
	3	74·48	57·43	3·04	344·05	9 30 „	15 29 „
	5	74·45	57·09	3·01	349·31	9 19 „	15 18 „
	7	74·43	56·74	2·98	354·55	9 9 „	15 8 „
	9	74·41	56·39	2·96	359·77	8 58 „	14 57 „
	11	74·39	56·04	2·93	4·98	8 48 „	14 47 „
	13	74·39	55·69	2·90	10·17	8 38 „	14 37 „
	15	74·38	55·33	2·87	15·35	8 27 „	14 26 „
	17	74·38	54·98	2·85	20·51	8 17 „	14 16 „
	19	74·39	54·62	2·82	25·66	8 7 „	14 6 „
	21	74·40	54·26	2·79	30·79	7 57 „	13 55 „
	23	74·42	53·90	2·77	35·90	7 47 „	13 45 „
	25	74·44	53·54	2·74	41·00	7 36 „	13 35 „
	27	74·46	53·19	2·71	46·09	7 26 „	13 25 „
	29	74·49	52·83	2·69	51·16	7 16 „	13 15 „
	31	74·53	52·48	2·66	56·21	7 6 „	13 5 „
Feb.	2	74·57	52·13	2·64	61·26	6 56 „	12 55 „
	4	74·61	51·78	+2·61	66·29	6 46 W	12 45 E

The rectangular coordinates x and y of the satellite in reference to the axes of *Jupiter's* disc, or its apparent distances from the polar axis and from the direction of the equatorial diameter of the disc, are found by

$$x = a \sin (l - \mathrm{L})$$
$$y = b \cos (l - \mathrm{L}),$$

where a and b denote the semi-axes of the apparent orbit and $l-\mathrm{L}$ the satellite's orbital longitude reckoned from the point which is in superior conjunction in reference to the Earth. The differences between successive values of $l-\mathrm{L}$ for an interval of two days vary between 1445°·03 and 1445°·58. The assumed daily rate of orbital motion is 722°·645, corresponding to a period of revolution of $11^{h}\ 57^{m}\ 21^{s}\cdot88$, the uncertainty of which is probably within a second of time, and will be reduced to a fraction by the first trustworthy measurements of x made at a sufficient distance both before and after a greatest elongation. The position-angle P+90° of the equatorial diameter of the disc is added, as it is desirable that the rectangular coordinates of the satellite should be measured in the computed directions of the axes of the disc.

Col. Cooper's Observatory:
Markree, Collooney, Ireland.

Erratum in Mr. Stone's Paper, "Monthly Notices," Vol. LIII., page 423, 15th line from top.

For Moon's mass $= n^2a^3$, *read* Earth's mass + Moon's mass $= n^2a^3$.

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Expression of the Radius Vector of the Moon's Orbit as disturbed by the Sun to the fifth order of small quantities.

By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

In the second volume of Delaunay's Lunar Theory the expression for $\frac{1}{r}$ is given to the fifth order of the small quantities involved. In some astronomical researches the expression for r is required, and I have thought it might be useful to other astronomers to publish the expression which I have obtained for r to the fifth order.

$$\frac{r}{a} =$$

$$(1)\ \left[1+\frac{e^2}{2}-\left(\frac{1}{6}-\frac{355}{384}e^2+\frac{e'^2}{4}-\frac{ee'^2}{2}\right)m^2+\frac{1905}{256}m^2e^2+\left(\frac{331}{288}-\frac{179}{144}e\right)m^4 + \frac{83}{16}m^5\right].$$

$$(2)\ \cos l\left[-e+\frac{3}{8}e^3-\frac{5}{192}e^5-\frac{5}{2}e\gamma^4+\frac{5}{4}e^2\gamma^2+\left(\frac{11}{12}e+\frac{181}{128}e^3-\frac{19}{32}e\gamma^2+\frac{7}{8}ee'^2\right)m^2 + \frac{405}{64}m^3e+\frac{8099}{256}m^4e\right].$$

$$(3)\ \cos 2l\left[-\frac{e^2}{2}+\frac{e^4}{3}+\frac{m^2e^2}{3}+\frac{1035}{128}m^3e^2\right].$$

(4) $\cos 2D\left[\left(-\frac{15}{8}e^2+\frac{45}{32}e^4+\frac{75}{16}e^2e'^2+\frac{15}{4}e^2\gamma^2\right)m-\left(1+\frac{173}{32}e^2-2\gamma\right.\right.$
$\left.\left.-\frac{5}{2}e'^2\right)m^2-\left(\frac{19}{6}+\frac{32185}{1536}e^2-\frac{29}{6}\gamma^2-\frac{239}{12}e'^2\right)m^3-\frac{125}{18}m^4-\frac{709}{54}m^5\right].$

(5) $\cos(2D-l)\left[\left(-\frac{15}{8}e+\frac{15}{16}e^3+\frac{75}{16}ee'^2+\frac{15}{4}e\gamma^2\right)m-\left(\frac{155}{32}e-\frac{423}{128}e^3\right.\right.$
$\left.\left.-\frac{305}{32}ee'^2-\frac{145}{8}e\gamma^2\right)m^2-\frac{23689}{1536}m^3e-\frac{10111881}{18432}m^4e\right].$

(6) $\cos l'\left[\left(\frac{3}{2}e'+\frac{27}{2}e^2e'-9e'\gamma^2\right)m^2-\frac{409}{16}m^4e'\right].$

(7) $\cos(l-l')\left[\left(-\frac{21}{8}ee'-\frac{9}{64}e^3e'+\frac{63}{4}ee'\gamma^2\right)m-\frac{1209}{64}m^2ee'-\frac{3091}{32}m^3ee'\right].$

(8) $\cos(l+l')\left[\left(\frac{21}{8}ee'+\frac{9}{64}e^3e'-\frac{63}{4}ee'\gamma^2\right)m+\frac{741}{64}m^2ee'+\frac{7139}{128}m^3ee'\right].$

(9) $\cos 3l\left[-\frac{3}{8}e^3+\frac{45}{128}e^5+\frac{5}{16}m^2e^3\right].$

(10) $\cos(2F-l)\left[\frac{5}{2}e\gamma^2+10e\gamma^4-\frac{95}{16}e^3\gamma^2-\frac{135}{16}me\gamma^2+\frac{209}{384}m^2e\gamma^2\right].$

(11) $\cos(2D-l')\left[-\frac{35}{8}me^2e'-\left(\frac{7}{2}e'+\frac{743}{32}e^2e'-7e'\gamma^2\right)m^2-\frac{157}{8}m^3e'\right.$
$\left.-\frac{3365}{48}m^4e'\right].$

(12) $\cos(2D+l')\left[\frac{15}{8}me^2e'+\left(\frac{e'}{2}+\frac{199}{32}e^3e'-e'\gamma^2\right)m^2+\frac{91}{24}m^3e'+\frac{1025}{144}m^4e'\right].$

(13) $\cos(2D+l)\left[-\frac{135}{64}me^3-\left(\frac{17}{16}e+\frac{1567}{256}e^3-\frac{85}{32}ee'^2-\frac{17}{8}e\gamma^2\right)m^2-\frac{151}{48}m^3e\right.$
$\left.-\frac{7981}{1152}m^4e\right].$

(14) $\cos(2D-l-l')\left[\left(-\frac{35}{8}ee'+\frac{35}{16}e^3e'+\frac{35}{4}ee'\gamma^2\right)m-\frac{1045}{64}m^2ee'\right.$
$\left.-\frac{32719}{768}m^3ee'\right].$

(15) $\cos(2D-l+l')\left[\left(\frac{15}{8}ee'-\frac{15}{16}e^3e'-\frac{15}{4}ee'\gamma^2\right)m+\frac{65}{64}m^2ee'-\frac{54613}{768}m^3ee'\right].$

(16) $\cos D\frac{a}{a'}\left[\left(\frac{15}{16}+\frac{45}{16}e^2+\frac{15}{16}e'^2-\frac{165}{16}\gamma^2\right)m+\frac{81}{16}m^2+\frac{5497}{256}m^3\right].$

(17) $\cos(D+l')\frac{a}{a'}\left[-\frac{5}{4}e'-\frac{25}{8}e^2e'+\frac{15}{4}e'\gamma^2+\frac{45}{8}me'-\frac{6553}{192}m^2e'\right].$

(18) $\cos 2l'\left[\frac{9}{4}m^2e'^2\right].$ (19) $\cos(l-2l')\left[-\frac{63}{32}mee'^2-\frac{5211}{256}m^2ee'^2\right].$

(20) $\cos(l+2l')\left[\frac{63}{32}mee'^2+\frac{1389}{256}m^2ee'^2\right].$

(21) $\cos(2l-l')\left[-\frac{21}{8}me^2e'-\frac{1233}{64}m^2e^2e'\right]$.

(22) $\cos(2l+l')\left[\frac{21}{8}me^2e'+\frac{717}{64}m^2e^2e'\right]$. (23) $\cos 4l\left[-\frac{e^4}{3}\right]$.

(24) $\cos 2F\left[\frac{5}{2}e^2\gamma^2-\frac{135}{16}me^2\gamma^2-2m^2\gamma^2+3m^2\gamma^2\right]$.

(25) $\cos(2D-2l')\left[-\frac{255}{32}me^2e'^2-\frac{17}{2}m^2e'^2-\frac{799}{12}m^2e'^2\right]$.

(26) $\cos(2D+l-l')\left[-\frac{315}{64}me^2e'-\frac{119}{32}m^2ee'-\frac{2879}{128}m^2ee'\right]$.

(27) $\cos(2D+l+l')\left[\frac{135}{64}me^2e'+\frac{17}{32}m^2ee'+\frac{2597}{384}m^2ee'\right]$.

(28) $\cos(2D+2l)\left[-\frac{5}{2}me^4-\frac{19}{16}m^2e^2-\frac{167}{48}m^2e^2\right]$.

(29) $\cos(2D-l-2l')\left[-\frac{255}{32}mee'^2-\frac{9835}{256}m^2ee'^2\right]$.

(30) $\cos(2D-l+2l')\left[\frac{45}{32}mee'^2+\frac{6219}{256}m^2ee'^2\right]$.

(31) $\cos(2D-2l)\left[\left(\frac{15}{8}e^2-\frac{15}{16}e^4-\frac{75}{16}e^2e'^2-\frac{15}{4}e^2\gamma^2\right)m+\frac{315}{32}m^2e^2+\frac{49209}{1536}m^2e^2\right]$.

(32) $\cos(2D-3l)\left[\frac{135}{64}me^3+\frac{6041}{768}m^2e^3\right]$.

(33) $\cos(2D-2F)\left[-\frac{75}{8}me^2\gamma^2+3m^2\gamma^2-\frac{9}{4}m^2\gamma^2\right]$.

(34) $\cos(2D-2F+l)\left[\frac{33}{16}me\gamma^2-\frac{1207}{128}m^2e\gamma^2\right]$.

(35) $\cos(2D-2F-l)\left[\frac{21}{8}me\gamma^2+\frac{15}{32}m^2e\gamma^2\right]$.

(36) $\cos 4D\left[-\frac{285}{64}m^2e^2-\frac{3}{8}m^4-\frac{1217}{480}m^3\right]$.

(37) $\cos(4D-l)\left[-\frac{2025}{512}m^2e^3-\frac{255}{128}m^3e-\frac{22887}{1536}m^4e\right]$.

(38) $\cos(4D-2l)\left[-\frac{225}{128}m^2e^2-\frac{3315}{256}m^3e^2\right]$.

(39) $\cos(D+l)\frac{a}{a'}\left[\frac{15}{16}me+6m^2e\right]$.

(40) $\cos(D+l+l')\frac{a}{a'}\left[-\frac{5}{4}ee'+\frac{45}{8}mee'\right]$.

(41) $\cos 3D\frac{a}{a'}\left[-\frac{25}{64}m^2-\frac{5}{128}m^3\right]$.

(42) $\cos(2l-2l')\left[-\frac{63}{32}me^2e'^2\right]$.

(43) $\cos(2l+2l')\left[\frac{63}{32}me^2e'^2\right]$.

(44) $\cos(3l-l')\left[-\frac{189}{64}me^3e'\right]$.

(45) $\cos(3l+l')\left[\frac{189}{64}me^3e'\right]$.

(46) $\cos 5l\left[-\frac{125}{384}e^5\right]$.

(47) $\cos(2F-l')\left[-3m^2e'\gamma^2\right]$.

(48) $\cos(2F+l')\left[-3m^2e'\gamma^2\right]$.

(49) $\cos(2F+l)\left[\frac{45}{16}e^2\gamma^2-\frac{17}{8}m^2e\gamma^2\right]$.

(50) $\cos(2F-l-l')\left[-\frac{75}{16}mee'\gamma^2\right]$.

(51) $\cos(2F-l+l')\left[\frac{75}{16}mee'\gamma^2\right]$.

(52) $\cos(2D+2l')\left[\frac{45}{32}me^2e'^2+\frac{3}{4}m^3e'^2\right]$.

(53) $\cos(2D+l-2l')\left[-\frac{289}{32}m^2ee'^2\right]$.

(54) $\cos(2D+2l-l')\left[-\frac{133}{32}m^2e^2e'\right]$.

(55) $\cos(2D+2l+l')\left[\frac{19}{32}m^2e^2e'\right]$.

(56) $\cos(2D+3l)\left[-\frac{535}{384}m^2e^3\right]$.

(57) $\cos(2D-2l-l')\left[\frac{35}{8}me^2e'+\frac{925}{32}m^2e^2e'\right]$.

(58) $\cos(2D-2l+l')\left[-\frac{15}{8}me^2e'+\frac{45}{32}m^2e^2e'\right]$.

(59) $\cos(2D-3l-l')\left[\frac{315}{64}me^3e'\right]$.

(60) $\cos(2D-3l+l')\left[-\frac{135}{64}me^3e'\right]$.

(61) $\cos(2D-4l')\left[\frac{65}{32}me^4\right]$.

(62) $\cos(2D+2F-l)\left[\frac{85}{32}m^2e\gamma^2\right]$.

(63) $\cos(2D+2F-2l)\left[\frac{75}{16}me^2\gamma^2\right]$.

(64) $\cos(2D-2F-l')\left[\frac{21}{2}m^2e'\gamma^2\right]$.

(65) $\cos(2D-2F+l')\left[-\frac{3}{2}m^2e'\gamma^2\right]$.

(66) $\cos(2D-2F+l-l')\left[\frac{77}{16}mee'\gamma^2\right]$.

(67) $\cos(2D-2F+l+l')\left[-\frac{33}{16}mee'\gamma^2\right]$.

(68) $\cos(2D-2F+2l)\left[\frac{33}{16}me^2\gamma^2\right]$.

(69) $\cos(2D-2F-l-l')\left[\frac{49}{8}mee'\gamma^2\right]$.

(70) $\cos(2D-2F-l+l')\left[-\frac{21}{8}mee'\gamma^2\right]$.

(71) $\cos(2D-2F-2l)\left[\frac{21}{8}me^2\gamma^2\right]$.

(72) $\cos(4D-l')\left[-\frac{21}{8}m^4e'\right]$.

(73) $\cos(4D+l')\left[\frac{3}{8}m^4e'\right]$.

(74) $\cos(4D+l)\left[-\frac{245}{256}m^4e\right]$.

(75) $\cos(4D-l-l')\left[-\frac{2975}{256}m^2ee'\right]$. (76) $\cos(4D-l+l')\left[\frac{765}{256}m^2ee'\right]$.

(77) $\cos(4D-2l-l')\left[-\frac{525}{64}m^2e^2e'\right]$. (78) $\cos(4D-2l+l')\left[\frac{225}{64}m^2e^2e'\right]$.

(79) $\cos(4D-3l)\left[-\frac{225}{512}m^3e^3\right]$. (80) $\cos(4D-2F)\left[-\frac{3}{2}m^2\gamma^2\right]$.

(81) $\cos(4D-2F-l)\left[-\frac{45}{32}m^2e\gamma^2\right]$. (82) $\cos(D-l')\frac{a}{a'}\left[-\frac{15}{16}me'+\frac{1057}{64}m^2e'\right]$.

(83) $\cos(D-2l')\frac{a}{a'}\left[-\frac{435}{128}me'^2\right]$. (84) $\cos(D+2l')\frac{a}{a'}\left[\frac{255}{128}me'^2\right]$.

(85) $\cos(D+l-l')\frac{a}{a'}\left[-\frac{15}{8}mee'\right]$. (86) $\cos(D+2l)\frac{a}{a'}\left[\frac{135}{128}me^2\right]$.

(87) $\cos(D+2l+l')\frac{a}{a'}\left[-\frac{45}{32}e^2e'\right]$.

(88) $\cos(D-l)\frac{a}{a'}\left[-\frac{15}{16}me-\frac{1233}{128}m^2e\right]$.

(89) $\cos(D-2l)\frac{a}{a'}\left[-\frac{465}{128}me^2\right]$. (90) $\cos(D-2l+l')\frac{a}{a'}\left[\frac{115}{32}e^2e'\right]$.

(91) $\cos(D-2F)\frac{a}{a'}\left[-\frac{45}{8}m\gamma^2\right]$. (92) $\cos(D-2F+l')\frac{a}{a'}\left[\frac{5}{3}e'\gamma^2\right]$.

(93) $\cos(3D-l')\frac{a}{a'}\left[-\frac{125}{64}m^2e'\right]$. (94) $\cos(3D+l')\frac{a}{a'}\left[-\frac{15}{16}m^2e'\right]$.

(95) $\cos(3D+l)\frac{a}{a'}\left[-\frac{35}{64}m^2e\right]$. (96) $\cos(3D-l)\frac{a}{a'}\left[\frac{775}{128}m^2e\right]$.

(97) $\cos(3D-l+l')\frac{a}{a'}\left[-\frac{75}{32}mee'\right]$. (98) $\cos(3D-2l)\frac{a}{a'}\left[\frac{175}{64}me^2\right]$.

(99) $\cos(3D-2F)\frac{a}{a'}\left[\frac{25}{16}m\gamma^2\right]$. (100) $\cos(2F-2l)\left[-\frac{5}{2}e^2\gamma^2+\frac{135}{16}me^2\gamma^2\right]$

(101) $\cos(2D-2l-2l')\left[\frac{255}{32}me^2e'^2\right]$.

(102) $\cos(2D-2l+2l')\left[-\frac{45}{32}me^2e'^2\right]$.

(103) $\cos(D-l+l')\frac{a}{a'}\left[\frac{5}{4}ee'-\frac{45}{8}mee'\right]$.

(104) $\cos(D-l-l')\frac{a}{a'}\left[\frac{75}{32}mee'\right]$.

Radcliffe Observatory, Oxford:
1893 *June* 9.

Occultation of Saturn, 1893 *May* 25, *observed at Sydney Observatory.*

(*Communicated by H. C. Russell, B.A., F.R.S., Government Astronomer.*)

Atmosphere was fine and clear, definition good. The definition of the Moon's limb as it passed over the planet at ingress was remarkably sharp as I saw it with a power of 400 on the 11½-inch Equatoreal. Mr. Sellors observed with a 6-inch Grubb telescope, and Mr. Lenehan with a 3-inch (private) telescope. Time used, Sydney mean time.

Ingress.	H.C.R.	H.A.L.	R.P.S.
	h m s	h m s	h m s
First contact ring	5 19 3·4	...	...
„ „ limb	...	5 19 22·0	5 19 16·4
Planet bisected	5 19 36·4	...	...
Last contact limb	5 19 58·4	5 20 7·0	5 19 58·2
„ „ ring	...	...	5 20 13·1

At egress Mr. Russell attended to photographs, Mr. Sellors observed with the 7½-inch guiding telescope of the star camera, Mr. Lenehan with the 3-inch.

Egress.	H.A.L.	R.P.S.	
	h m s	h m s	
First contact ring ...	6 39 10	6 39 5	
„ „ limb ...	...	...	
Last contact limb ...	...	6 39 50	uncertain to the extent of 4 or 5 seconds.
„ „ ring ...	6 40 4	6 40 15	

Observatory, Sydney:
1893 *May* 26.

Results of Micrometer Comparisons of Saturn and γ^1 *Virginis in* 1893 *April.* By John Tebbutt.

Filar-micrometer comparisons were obtained of *Saturn* and the preceding or north component of γ *Virginis* with the 8-inch equatoreal on the evenings of April 3, 4, 5, 6, 8, 10, 11. On April 3, 4, 5, 10, 11, ten comparisons of the planet's preceding and north, and the same number of the following and south limbs were observed. On the 6th ten comparisons of the preceding and north limbs were secured, but, owing to clouds, the number of comparisons of the following and south limbs was limited to seven. On the 8th ten comparisons of the following and north, and the same number of the following and south limbs were made. On this date the preceding limb and the star crossed

the transit thread too near together for observation. It was difficult, indeed, on this occasion to observe the following limb, and the concluded differences of R.A. are therefore not so satisfactory as those obtained on the other dates. A magnifying power of 74 diameters was employed throughout, and the images—particularly on the 8th, 10th, and 11th—were steady and well defined. The accompanying table exhibits an abstract of the results of the observations. The observed differences of R.A. are corrected for the sidereal time of the transit of the semi-diameter as given in the *Nautical Almanac*, and for a small error in the perpendicularity of the micrometer threads; the observed differences of N.P.D. are corrected for the semi-diameter of the same ephemeris. The apparent places of the preceding component are also taken from the same. A comparison of the results with the places of the planet interpolated with second differences from page 260 of the *Nautical Almanac* leads me to infer that the tabular R.A. and N.P.D. are both a little too large. During an unusually good definition of the planet on April 11 I obtained four double measures of its diameter in N.P.D. with a power of 170. These measures gave 18″·90 as the diameter of the ball in N.P.D.

Results of Micrometric Comparisons of Saturn and γ^1 Virginis.

1893.	Windsor Mean Time.	Observed Diff. R.A. Planet's centre −Star.	Corrections for Refraction.	Corrections for Parallax.	Geocentric Apparent R.A. of Planet's Centre from Observation.	Geocentric Apparent R.A. of Planet's Centre from *Nautical Almanac*.	Diff. N.A.−Obs.
	h m s	m s	s	s	h m s	s	s
Apr. 3	10 53 31	+1 25·88	−0·01	−0·01	12 37 41·51	41·65	+0·14
„ 4	9 55 41	+1 9·57	−0·01	−0·03	12 37 25·18	25·26	+0·08
„ 5	9 13 39	+0 52·99	−0·01	−0·03	12 37 8·61	8·71	+0·10
„ 6	9 3 18	+0 36·05	−0·01	−0·03	12 36 51·67	51·85	+0·18
„ 8	10 43 51	+0 0·92	0·00	−0·01	12 36 16·58	16·88	+0·30
„ 10	8 53 28	−0 31·18	0·00	−0·03	12 35 44·47	44·68	+0·21
11	9 34 27	−0 48·27	0·00	−0·02	12 35 27·39	27·60	+0·21

1893.	Windsor Mean Time.	Observed Diff. N.P.D. Planet's Centre −Star.	Corrections for Refraction.	Corrections for Parallax.	Geocentric Apparent N.P.D. of Planet's Centre from Observation.	Geocentric Apparent N.P.D. of Planet's Centre from *Nautical Almanac*.	Diff. N.A.−Obs.
	h m s	′ ″	″	″	° ′ ″	″	″
Apr. 3	10 53 31	+15 14·2	+0·3	+0·5	91 7 8·1	9·4	+1·3
„ 4	9 55 41	+13 30·0	+0·3	+0·5	91 5 23·9	24·5	+0·6
„ 5	9 13 39	+11 43·9	+0·2	+0·5	91 3 37·7	39·0	+1·3
„ 6	9 3 18	+9 56·6	+0·2	+0·5	91 1 50·5	51·7	+1·2
„ 8	10 43 51	+6 14·6	+0·1	+0·5	90 58 8·4	10·4	+2·0
„ 10	8 53 28	+2 52·2	+0·1	+0·5	90 54 46·0	48·1	+2·1
„ 11	9 34 27	+1 5·0	0·0	+0·5	90 52 58·7	1·3	+2·6

Windsor, New South Wales:
1893 *June* 8.

Observations of the Comet Rordame-Quénisset (b 1893), made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East, or Sheepshanks, equatoreal, aperture 6·7 inches, by taking transits over two cross wires at right angles to one another, and each inclined 45° to the parallel of declination. Transits were sometimes taken also over a third wire bisecting the angle between the two other wires. Magnifying power 55.

The observations are corrected for refraction but not for parallax; they are also corrected for the error of inclination of the wires and for the motion of the comet.

Greenwich Mean Solar Time.	Observer.	☄ − ✱ R.A.	Log factor of Parallax.	Corr. for Refraction.	☄ − ✱ N.P.D.	Log factor of Parallax.	Corr. for Refraction.	No. of Comps.	Apparent R.A. of ☄.	Apparent N.P.D. of ☄.	Comp. ✱
1893. d h m s		m s		s	′ ″		″		h m s	° ′ ″	
July 11 10 51 14	C.D.	+1 35·11	9·5446	+0·03	− 3 33·9	0·8889	−0·9	3	...	...	*a*
11 11 2 31	,,	+0 45·06	9·5227	−0·13	+15 29·7	0·8963	+4·1	2	9 0 55·95	44 39 3·3	*b*
16 10 13 23	A.C.	+2 57·13	9·6274	−0·02	+ 2 41·6	0·8218	+0·3	3	10 43 46·83	55 55 15·7	*c*
16 10 13 23	,,	+2 1·99	9·6274	−0·03	+ 4 34·7	0·8218	+0·4	3	10 43 46·82	55 55 14·6	*d*
16 10 33 16	A.E.	+3 7·46	9·6141	−0·03	+ 4 25·0	0·8376	+0·4	1	10 43 57·15	55 56 59·2	*c*
16 10 33 16	,,	+2 12·16	9·6141	−0·05	+ 6 11·6	0·8376	+0·5	1	10 43 56·97	55 56 51·6	*d*
17 9 37 32	B.	−3 35·27	9·6350	+0·01	− 4 1·1	0·7903	−0·2	2	10 55 13·69	57 55 8·3	*e*
17 10 19 35	H.	−3 14·92	9·6184	0·00	− 0 26·6	0·8260	0·0	1	10 55 34·03	57 58 43·0	*e*
17 10 34 55	,,	+0 3·97	9·6085	+0·10	−10 45·6	0·8377	−1·5	2	10 55 40·24	57 59 47·6	*f*
17 10 38 24	C.D.	+0 5·52	9·6053	+0·10	−10 19·3	0·8401	−1·6	4	10 55 41·79	58 0 13·8	*f*
17 10 57 5	,,	−2 58·29	9·5902	−0·04	+ 2 38·1	0·8537	+0·7	1	10 55 50·62	58 1 48·4	*e*
21 9 28 24	B.	+2 35·08	9·6104	−0·02	+ 4 46·6	0·7946	+0·2	3	11 26 50·17	64 32 31·9	*g*

Greenwich Mean Solar Time.				Observer.	☄ − ✱ R.A.	Log factor of Parallax.	Corr. for Refraction.	☄ − ✱ N.P.D.	Log factor of Parallax.	Corr. for Refraction.	No. of Comps.	Apparent R.A. of ☄.	Apparent N.P.D. of ☄.	Comp.
1893.	d	h	m s		m s		s	′ ″		″		h m s	° ′ ″	
July	21	9	28 24	B.	+2 25·89	9·6104	0·00	+ 1 4·8	0·7946	0·0	3	11 26 50·40	64 32 35·6	*h*
	22	9	54 18	H.	−2 19·26	9·6027	−0·07	+10 37·7	0·8154	+0·9	4	11 32 16·30	65 52 33·0	*i*
	22	10	12 35	,,	−0 49·34	9·5976	+0·10	−11 11·0	0·8274	−1·8	2	11 32 20·24	65 53 25·1	*k*
	22	10	40 10	A.E.	−2 9·92	9·5845	−0·30	+12 43·5	0·8438	+2·9	2	11 32 25·41	65 54 40·8	*i*
	22	10	49 46	,,	−0 40·98	9·5778	+0·24	− 9 19·9	0·8495	−2·6	1	11 32 28·74	65 55 15·4	*k*
	27	9	41 17	A.C.	−4 42·97	9·5897	+0·08	− 9 33·1	0·8210	+0·9	3	11 50 26·70	70 54 37·0	*l*
Aug.	4	9	11 0	B.	−1 21·31	9·5795	+0·02	− 1 9·9	0·8252	+0·1	1	...	...	*m*
	4	9	11 7	,,	−0 49·36	9·5795	+0·03	− 2 21·6	0·8252	+0·1	3	12 4 59·04	75 48 44·7	*n*
	5	9	15 23	,,	−0 19·43	9·5783	+0·13	− 8 9·2	0·8285	+0·3	4	12 6 11·67	76 16 9·1	*o*
	5	9	15 24	,,	−1 28·22	9·5783	+0·06	− 4 23·8	0·8284	+0·1	3	12 6 11·59	76 16 14·5	*p*
	7	9	16 17	,,	−0 17·08	9·5763	+0·19	− 9 4·5	0·8322	+0·1	2	12 8 20·78	77 6 24·0	*q*
	8	9	8 3	A.C.	+0 25·21	9·5761	+0·12	− 5 46·4	0·8309	+0·2	1	12 9 19·10	77 29 2·4	*r*
	8	9	10 46	,,	+0 43·05	9·5759	−0·28	+13 49·3	0·8319	+0·2	2	12 9 20·44	77 29 17·0	*q*
	10	9	12 55	B.	−1 5·29	9·5737	−0·02	+ 0 44·3	0·8353	+0·1	3	12 11 6·68	78 12 10·2	*s*

Notes.

July 11, 16.—Comet very bright, apparently nearly circular.
July 16.—Nucleus north preceding centre.
July 27.—Comet still very bright. Visible in bright twilight.
Aug. 10.—Comet faint. Observations rather rough.

The initials H., A.C., B., C.D., A.E. are those of Mr. Hollis, Mr. Crommelin, Mr. Bryant, Mr. Davidson, and Miss Everett respectively.

Assumed Mean Places of the Comparison Stars.

Comparison Star.	Assumed R.A. 1893·0.	Assumed N.P.D. 1893·0.	Authority.
	h m s	° ′ ″	
a. B.D. + 45° 1675	8 59 2	44 42	Bonn Observations, vol. iv.
b. O.A. (N.), 9583	9 0 10·72	44 23 37·8	Oeltzen-Argelander (N).
c. W.B. (2) X., 789	10 40 49·04	55 52 39·7	Leiden Zones, 169, 281.
d. W.B. (2) X., 805	10 41 44·18	55 50 45·3	,, ,, 170, 284.
e. W.B. (2) X., 1143	10 58 48·22	57 59 14·7	,, ,, ,, ,,
f. W.B. (2) X., 1071	10 55 35·45	58 10 39·9	,, ,, ,, ,,
g. W.B. (2) XI., 412	11 24 14·33	64 27 48·2	Paris Catalogue and Second Armagh Catalogue.
h. W.B. (2) XI., 414	11 24 23·73	64 31 33·9	Paris Catalogue.
i. W.B. (2) XI., 632	11 34 34·83	65 41 57·0	Paris and Second Armagh Catalogues, and Berlin Zones, 64, 66, 246.
k. W.B. (2) XI., 600	11 33 8·68	66 4 40·4	Yarnall's Washington Catalogue, 1860, and Berlin Zones, 68, 70, 249.
l. W.B. (2) XI., 1041	11 55 8·77	71 4 9·3	Paris Catalogue.
m. B.D. + 14°, 2478	12 6 19	75 50	Bonn Observations, vol. iii.
n. W.B., XII., 41	12 5 47·59	75 51 5·3	First Glasgow Catalogue, Schjellerup's Catalogue, and Bonn Observations, vol. vi.
o. W.B., XII., 54	12 6 30·19	76 24 17·0	Schjellerup's Catalogue, 1865.
p. W.B., XII., 76	12 7 38·97	76 20 37·2	Weisse's Bessel, and Bonn Observations, vol. vi.
q. Lalande, 22932	12 8 36·90	77 15 27·1	Schjellerup's Catalogue, 1865.
r. W.B., XII., 95	12 8 53·01	77 34 47·2	Lalande and Weisse's Bessel.
s. W.B., XII., 145	12 12 11·23	78 11 24·2	Schjellerup's Catalogue, 1865.

Royal Observatory, Greenwich:
1893 *September* 18.

Data for Computing the Positions of the Satellites of Jupiter 1893–94.

By A. Marth.

The following data for computing the places of the satellites for the present apparition of *Jupiter* are a continuation of those for the two preceding apparitions in vols. li. and lii. of the *Monthly Notices*. The motions of the longitudes and of the arguments, and the inequalities corresponding to the arguments, are to be found on pages 524–539 of vol. li.

First Satellite.

Greenwich Noon.	Longitude. $l_1 - O$	S_1	Arguments. α_1	β_1	γ_1	δ_1	ϵ_1
1893.	°	°					
June 25	263·2927	+ ·0062	·0616	·765	·815	·148	·247
July 5	138·1823	62	·7346	·184	·463	·800	·271
15	13·0718	61	·4176	·602	·112	·453	·296
25	247·9614	61	·0807	·020	·760	·105	·321
Aug. 4	122·8510	+ ·0060	·7537	·438	·408	·757	·345
14	357·7405	60	·4267	·857	·057	·409	·370
24	232·6301	59	·0997	·275	·705	·062	·395
Sept. 3	107·5196	58	·7727	·693	·353	·714	·420
13	342·4092	58	·4457	·111	·002	·366	·444
23	217·2988	57	·1187	·530	·650	·018	·469
Oct. 3	92·1883	+ ·0057	·7917	·948	·298	·671	·494
13	327·0779	56	·4648	·366	·946	·323	·518
23	201·9674	56	·1378	·784	·595	·975	·543
Nov. 2	76·8570	55	·8108	·203	·243	·628	·568
12	311·7466	54	·4838	·621	·891	·280	·592
22	186·6361	54	·1568	·039	·540	·932	·617
Dec. 2	61·5257	+ ·0053	·8298	·457	·188	·584	·642
12	296·4152	52	·5028	·876	·836	·237	·666
22	171·3048	52	·1758	·294	·485	·889	·691
1894.							
Jan. 1	46·1944	51	·8489	·712	·133	·541	·716
11	281·0839	51	·5219	·130	·781	·193	·740
21	155·9735	50	·1949	·549	·430	·846	·765
31	30·8630	+ ·0049	·8679	·967	·078	·498	·790
Feb. 10	265·7526	49	·5409	·385	·726	·150	·815
20	140·6422	48	·2139	·803	·375	·803	·839
Mar. 2	15·5317	47	·8869	·222	·023	·455	·864
12	250·4213	47	·5600	·640	·671	·107	·889
22	125·3108	46	·2330	·058	·320	·759	·913
Apr. 1	0·2004	+ ·0045	·9060	·476	·968	·412	·938

	Inclination. γ_1	Node. $O - \Gamma_1$		Inclination. γ_1	Node. $O - \Gamma_1$
	°	°		°	°
1893 June 5	0·0086	126·1	1893 Nov. 2	0·0087	133·3
July 5	86	127·5	Dec. 2	88	134·9
Aug. 4	87	128·9	1894 Jan. 1	88	136·5
Sept. 3	87	130·3	31	88	138·1
Oct. 3	87	131·8	Mar. 2	89	139·7
Nov. 2	0·0087	133·3	Apr. 1	0·0089	141·3

First Satellite.

Greenwich Noon. 1893.	Arguments. ζ_1	η_1	θ_1
June 25	·033	·414	·241
July 5	·055	·434	·262
15	·077	·455	·283
25	·098	·476	·303
Aug. 4	·120	·497	·324
14	·142	·517	·344
24	·164	·538	·365
Sept. 3	·185	·559	·386
13	·207	·580	·406
23	·229	·600	·427
Oct. 3	·251	·621	·447
13	·272	·642	·468
23	·294	·663	·489
Nov. 2	·316	·683	·509
12	·338	·704	·530
22	·359	·725	·550
Dec. 2	·381	·745	·571
12	·403	·766	·592
22	·425	·787	·612
1894.			
Jan. 1	·446	·808	·633
11	·468	·828	·653
21	·490	·849	·674
31	·512	·870	·695
Feb. 10	·533	·891	·715
20	·555	·911	·736
Mar. 2	·577	·932	·756
12	·599	·953	·777
22	·620	·974	·798
Apr. 1	·642	·994	·818

Second Satellite.

Longitude. $l_2 - O$	S_2	Arguments. α_2	β_2
° 252·2013	° −·0017	·53081	·765
185·9485	19	·36732	·184
119·6958	20	·20382	·602
53·4430	22	·04033	·020
347·1903	−·0023	·87684	·438
280·9376	24	·71334	·857
214·6848	26	·54985	·275
148·4321	27	·38635	·693
82·1793	29	·22286	·111
15·9266	30	·05937	·530
309·6738	−·0032	·89587	·948
243·4211	33	·73238	·366
177·1683	34	·56889	·784
110·9156	36	·40539	·203
44·6629	37	·24190	·621
338·4101	39	·07841	·039
272·1574	−·0040	·91491	·457
205·9046	41	·75142	·876
139·6519	43	·58792	·294
73·3991	44	·42443	·712
7·1464	45	·26094	·130
300·8936	46	·09744	·549
234·6409	−·0048	·93395	·967
168·3882	49	·77046	·385
102·1354	50	·60696	·803
35·8827	51	·44347	·222
329·6299	53	·27998	·640
263·3772	54	·11648	·058
197·1244	−·0055	·95299	·476

	Inclination. γ_2	Node. $O - \Gamma_2$	
1893 June 5	° 0·4872	° 141·67	97
July 5	·4869	142·64	98
Aug. 4	·4867	143·62	98
Sept. 3	·4865	144·60	97
Oct. 3	·4862	145·57	98
Nov. 2	0·4860	146·55	

Second Satellite.

Greenwich Noon. 1893.	Arguments. γ_2	δ_2	ϵ_2	ζ_2	η_2	θ_2	ι_2	κ_2	λ_2
June 25	·498	·117	·289	·033	·914	·741	·747	·944	·772
July 5	·312	·933	·105	·055	·934	·762	·771	·802	·629
15	·127	·749	·921	·077	·955	·783	·796	·659	·486
25	·942	·564	·737	·098	·976	·803	·821	·516	·344
Aug. 4	·757	·380	·553	·120	·997	·824	·845	·373	·201
14	·571	·196	·369	·142	·017	·844	·870	·231	·058
24	·386	·012	·185	·164	·038	·865	·895	·088	·915
Sept. 3	·201	·828	·001	·185	·059	·886	·920	·945	·772
13	·016	·643	·817	·207	·080	·906	·944	·802	·629
23	·830	·459	·633	·229	·100	·927	·969	·660	·486
Oct. 3	·645	·275	·448	·251	·121	·947	·994	·517	·343
13	·460	·091	·264	·272	·142	·968	·018	·374	·200
23	·275	·906	·080	·294	·163	·989	·043	·231	·057
Nov. 2	·089	·722	·896	·316	·183	·009	·068	·089	·915
12	·904	·538	·712	·338	·204	·030	·092	·946	·772
22	·719	·354	·528	·359	·225	·050	·117	·803	·629
Dec. 2	·534	·169	·344	·381	·245	·071	·142	·660	·486
12	·348	·985	·160	·403	·266	·092	·166	·518	·343
22	·163	·801	·976	·425	·287	·112	·191	·375	·200
1894.									
Jan. 1	·978	·617	·792	·446	·308	·133	·216	·232	·057
11	·793	·432	·608	·468	·328	·153	·240	·089	·914
21	·607	·248	·423	·490	·349	·174	·265	·947	·771
31	·422	·064	·239	·512	·370	·195	·290	·804	·628
Feb. 10	·237	·880	·055	·533	·391	·215	·315	·661	·486
20	·052	·696	·871	·555	·411	·236	·339	·518	·343
Mar. 2	·866	·511	·687	·577	·432	·256	·364	·376	·200
12	·681	·327	·503	·599	·453	·277	·389	·233	·057
22	·496	·143	·319	·620	·474	·298	·413	·090	·914
Apr. 1	·311	·959	·135	·642	·494	·318	·438	·947	·771

		Inclination. γ_2	Node. $\odot-\Gamma_2$	
1893	Nov. 2	0°·4860	146°·55	98
	Dec. 2	·4858	147·53	98
1894	Jan. 1	·4856	148·51	98
	31	·4854	149·49	98
	Mar. 2	·4853	150·47	98
	Apr. 1	0·4851	151·45	

Third Satellite.

Greenwich Noon.	Longitude. l_3-O	S_3	Arguments. α_3	β_3	γ_3	δ_3	ϵ_3
1893.	°	°					
June 25	156·6555	−·0039	·8518	·0240	·7654	·269	·179
July 5	299·8317	41	·2493	·4216	·1837	·068	·618
15	83·0078	43	·6468	·8193	·6019	·866	·057
25	226·1839	45	·0443	·2170	·0202	·665	·496
Aug. 4	9·3600	−·0046	·4418	·6146	·4384	·463	·935
14	152·5361	48	·8394	·0123	·8567	·262	·374
24	295·7122	50	·2369	·4099	·2749	·060	·813
Sept. 3	78·8883	52	·6344	·8076	·6932	·859	·252
13	222·0644	53	·0319	·2052	·1114	·657	·691
23	5·2405	55	·4294	·6029	·5297	·456	·130
Oct. 3	148·4166	−·0057	·8269	·0006	·9479	·254	·569
13	291·5927	58	·2244	·3982	·3662	·053	·008
23	74·7688	60	·6219	·7959	·7844	·851	·447
Nov. 2	217·9449	61	·0194	·1935	·2027	·650	·886
12	1·1200	63	·4170	·5912	·6209	·448	·325
22	144·2971	65	·8145	·9888	·0392	·247	·764
Dec. 2	287·4732	−·0066	·2120	·3865	·4575	·045	·203
12	70·6493	68	·6095	·7841	·8757	·844	·642
22	213·8254	69	·0070	·1818	·2940	·642	·081
1894.							
Jan. 1	357·0015	71	·4045	·5795	·7122	·441	·520
11	140·1776	72	·8020	·9771	·1305	·239	·959
21	283·3537	73	·1995	·3748	·5487	·038	·398
31	66·5298	−·0075	·5971	·7724	·9670	·836	·837
Feb. 10	209·7059	76	·9946	·1701	·3852	·635	·276
20	352·8820	78	·3921	·5677	·8035	·433	·715
Mar. 2	136·0581	79	·7896	·9654	·2217	·232	·154
12	279·2343	80	·1871	·3631	·6400	·030	·593
22	62·4104	82	·5846	·7607	·0582	·829	·032
Apr. 1	205·5865	−·0083	·9821	·1584	·4765	·627	·471

	Inclination. γ_3	Node. $O-\Gamma_3$		Inclination. γ_3	Node. $O-\Gamma_3$
	°	°		°	°
1893 June 5	0·1289	123·27	1893 Nov. 2	0·1273	124·36
July 5	·1285	123·48	Dec. 2	·1270	124·59
Aug. 4	·1282	123·69	1894 Jan. 1	·1268	124·83
Sept. 3	·1279	123·91	31	·1266	125·07
Oct. 3	·1276	124·13	Mar. 2	·1264	125·31
Nov. 2	0·1273	124·36	Apr. 1	0·1262	125·56

Greenwich Noon.		*Third Satellite.* Arguments. ζ_3	η_3	θ_3	ι_3	*Fourth Satellite.* Longitude. l_4-O	S_4	Arg. ω_4
1893.						°	°	
June	25	·033	·414	·241	·732	239·7944	−·0190	·25492
July	5	·055	·434	·262	·129	95·5051	·0194	·85407
	15	·077	·455	·283	·525	311·2159	·0198	·45321
	25	·098	·476	·303	·922	166·9266	·0202	·05235
Aug.	4	·120	·497	·324	·318	22·6373	−·0206	·65149
	14	·142	·517	·344	·715	238·3481	·0210	·25063
	24	·164	·538	·365	·111	94·0588	·0214	·84978
Sept.	3	·185	·559	·386	·508	309·7696	·0218	·44892
	13	·207	·580	·406	·904	165·4803	·0222	·04806
	23	·229	·600	·427	·301	21·1910	·0226	·64720
Oct.	3	·251	·621	·447	·697	236·9018	−·0229	·24634
	13	·272	·642	·468	·094	92·6125	·0233	·84549
	23	·294	·663	·489	·490	308·3233	·0237	·44463
Nov.	2	·316	·683	·509	·887	164·0340	·0240	·04377
	12	·338	·704	·530	·283	19·7447	·0244	·64291
	22	·359	·725	·550	·680	235·4555	·0248	·24205
Dec.	2	·381	·745	·571	·076	91·1662	−·0251	·84120
	12	·403	·766	·592	·473	306·8770	·0254	·44034
	22	·425	·787	·612	·869	162·5877	·0258	·03948
1894.								
Jan.	1	·446	·808	·633	·266	18·2984	·0261	·63862
	11	·468	·828	·653	·662	234·0092	·0265	·23776
	21	·490	·849	·674	·059	89·7199	·0268	·83691
	31	·512	·870	·695	·455	305·4307	−·0271	·43605
Feb.	10	·533	·891	·715	·852	161·1414	·0274	·03519
	20	·555	·911	·736	·248	16·8521	·0277	·63433
Mar.	2	·577	·932	·756	·645	232·5629	·0281	·23347
	12	·599	·953	·777	·041	88·2736	·0284	·83262
	22	·620	·974	·798	·438	303·9844	·0287	·43176
Apr.	1	·642	·994	·818	·834	159·6951	−·0290	·03090

	Inclination. γ_4	Node. $O-\Gamma_4$
1893.	°	°
June 5	0·3492	28·51
July 5	·3490	28·45
Aug. 4	·3487	28·40
Sept. 3	·3484	28·36
Oct. 3	·3481	28·31
Nov. 2	0·3477	28·27

Fourth Satellite.

Greenwich Noon. 1893.	Arguments. β_4	γ_4	δ_4	ϵ_4	ζ_4	η_4	θ_4
June 25	·269	·583	·604	·859	·514	·034	·186
July 5	·068	·182	·199	·053	·713	·251	·386
15	·866	·781	·794	·247	·913	·468	·585
25	·665	·380	·388	·441	·112	·685	·785
Aug. 4	·463	·979	·983	·634	·312	·902	·984
14	·262	·578	·578	·828	·511	·118	·184
24	·060	·177	·172	·022	·710	·335	·383
Sept. 3	·859	·776	·767	·216	·910	·552	·583
13	·657	·375	·362	·410	·109	·769	·782
23	·456	·974	·956	·603	·308	·985	·982
Oct. 3	·254	·573	·551	·797	·508	·202	·182
13	·053	·172	·145	·991	·707	·419	·381
23	·851	·771	·740	·185	·907	·636	·581
Nov. 2	·650	·370	·335	·378	·106	·852	·780
12	·448	·969	·929	·572	·305	·069	·980
22	·247	·568	·524	·766	·505	·286	·179
Dec. 2	·045	·167	·119	·960	·704	·503	·379
12	·844	·766	·713	·154	·903	·720	·578
22	·642	·365	·308	·347	·103	·936	·778
1894.							
Jan. 1	·441	·964	·902	·541	·302	·153	·977
11	·239	·563	·497	·735	·502	·370	·177
21	·038	·162	·092	·929	·701	·587	·376
31	·836	·761	·686	·122	·900	·803	·576
Feb. 10	·635	·360	·281	·316	·010	·020	·775
20	·433	·959	·876	·510	·299	·237	·975
Mar. 2	·232	·558	·470	·704	·498	·454	·174
12	·030	·157	·065	·898	·698	·670	·374
22	·829	·756	·660	·091	·897	·887	·573
Apr. 1	·627	·355	·254	·285	·097	·104	·773

	Inclination. γ_4	Node. $\Omega-\Gamma_4$
	°	°
1893 Nov. 2	0·3477	28·27
Dec. 2	·3473	28·23
1894 Jan. 1	·3469	28·20
31	·3465	28·17
Mar. 2	·3461	28·15
Apr. 1	0·3457	28·13

Col. Cooper's Observatory:
Markree, Collooney, Ireland.

Errata in Greenwich Observations of Comets, Monthly Notices, vol. liii. p. 515.

Comparison of Comet Swift with Star c:—𝒞 − * N.P.D. (both observers), also deduced Apparent N.P.D. of 𝒞 (both observers), are all 50″·0 too great, viz.:—

for 9′ 39″·9 *read* 8′ 49″·9, *for* 9′ 43″·8 *read* 8′ 53″·8
for 70° 29′ 29″·3 *read* 70° 28′ 39″·3, *for* 70° 29′ 33″·1 *read* 70° 28′ 43″·1

Erratum in Mr. Marth's Paper, Monthly Notices, vol. liii. p. 420, l. 8, *for* Pannekoch *read* Pannekoek.

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